تجهيز النظارات الطبية

Glasses Despensing



Aseel O. Hamadeh
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OSMANYBOOK

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الاهداء

إلى كل من ساعدنا في نشر هذا الكتاب ، إلى عائلتينا ، إلى أصدقائنا وزملائنا في العمل، وأيضا إلى طلابنا نهدي هذا الكتاب

For all whom helped us to puplish this book, to our family, for our friends and our work team, also for our students we gift this book

Chapter One
lenses Materials

Introduction

Optical lenses are defined as transparent component made from optical materials and cured to converge or diverge rays come from an object.

Functions of lenses:

1. Correct refractive errors
2. Protect the eye from harmful rays
3. Protect the eye from occupational hazards

Materials of optical lenses:

1. Glass
2. Plastic

Glass lenses

The development of optical glass:

Glass has two properties that make it especially suitable for optical uses. It is transparent to the visible spectrum, and its surface may be worked so that they are also transparent and nonscattering.

The invention of spectacles (if we define spectacle as two lenses mounted in a frame and used for the correction of ametropia) apparently occurred late in the thirteen century.

The early lenses were apparently used only for the correction of presbyopia. However, during this time, good quality homogeneous optical glass was not available.

The critical properties of optical glass:

1. The refractive index (n)

$$N = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in an optical medium}}$$

2. Dispersion expressed by Abbe number (v)
3. Specific gravity: weight of material per unit volume

Types of glass lenses:

The term "crown" and "flint" applied to optical glasses have lost their original meanings.

Now, arbitrarily, glasses with abbe numbers greater than 50 are called crown glasses, and glasses having abbe numbers less than 50 are called flint glass.

Main varieties of optical glass are:

1. Crown glass
2. Flint glass
3. Barium crown glass

Crown glass

Compositions of crown glass:

1. Silica (sand): 70%
2. Sodium oxide (soda) : 14-16%
3. Calcium oxide (lime) : 11-13%
4. Potassium, borax, antimony, arsenic: small percentage

Properties of crown glass:

1. Refractive index: 1.523
2. Abbe value: 59

Materials added to crown glass to protect from IR and UV:

1. Ferrous oxide: absorbs UV and IR, and gives the lens green or blue-green color
2. Thorium oxide: protect from UV
3. Uric oxide: protect from IR
4. The lead: protect the eye from X-ray

Flint glass

Compositions of flint glass:

1. Lead oxide: 45-65%
2. Silica : 25-45%
3. Soda, potassium oxide: 10%

Properties of flint glass:

1. Refractive index: 1.58-1.69
2. Abbe value: 30- 40

Barium crown glass

Compositions of barium crown glass:

1. Barium oxide
2. Silica
3. Soda, potassium oxide

Properties of barium crown glass:

1. Refractive index: 1.541-1.616
2. Abbe value: 55-59

Note: In recent years, many specific varieties of glass, having special properties, have been developed. These include high-index glasses with refractive indecies of 1.60, 1.70 and 1.80.

These glasses have a high content of titanium oxide (which is useful for reducing the thickness)

Glass	Refractive index	Abbe no.	Sagital gravity	Uses
Crown	1.523	58.9	2.54	Single vision, carrier of multifocal
Light barium crown	1.573	57.4	3.21	Intermediate segment of trifocal
Dense barium crown	1.616	55.1	3.36	Near segment of bifocals and trifocals
Dense flint	1.649	33.8	3.90	Segment of bifocals
Extra dense flint	1.69	30.9	4.23	Segment of bifocals

Advantages of glass lenses:

1. Resist scratching
2. Not easily affected by environmental factors
3. Its thickness is less than plastic

Disadvantages of glass lenses:

1. Heavy
2. Easy to break
3. Increasing the surface reflection

Plastic lenses

Introduction:

Plastic materials defined as a polymeric material (usually organic) of large molecular weight which can be shaped.

Because of negative connotation of the term “plastic”, ophthalmic lens manufacturers have used other terms to describe lenses made of plastic materials, such as:

1. Organic lenses
2. Resin lenses
3. Hard resin lenses

Development of optical plastic:

Although plastic materials have been available for many years, plastic lenses are relatively new compared with glass lenses. They provided little competition to glass lenses until the decade of the 1970s.

2nd world war served as impetus for the development of the plastic industry. One of the plastic materials developed during 2nd world war was (PMMA) which had the advantage of being much more shatter proof than non tempered glass, it had the unfortunate disadvantage of scratching more easily.

Another plastic material developed during 2nd world war, also for use in military applications, was the material allyl diglycol carbonate, known as Columbia Resin 39, or CR-39.

In 1957 general electric developed a new plastic material, a polycarbonate resin, called lexan. This material of great mechanical strength and high service temperatures was first produced in ophthalmic lenses in 1978 by Gentex Corporation.

<u>CR- 39</u>

Properties of CR-39 lenses:

1. Refractive index: 1.498
2. Abbe value: 58
3. Specific gravity: 1.32

Polycarbonate:

Properties of polycarbonate lenses:

1. Refractive index: 1.586
2. Abbe value: 30
3. Specific gravity: 1.20

Advantages of plastic lenses:

1. Light in weight
2. Resistance to pitting
3. Tint ability

Disadvantages of plastic lenses:

1. Scratching
2. Easily affected by environmental factors

High index plastic

Properties of high index plastic lenses:

1. Refractive index: 1.54 – 1.66
2. Abbe value: 32 – 47
3. Specific gravity: 1.21 – 1.35

Advantages of high index plastic lenses:

a. Reduced thickness and weight

b. Enhance the cosmetic appearance for high power prescriptions.

Disadvantages of high index plastic lenses:

- High chromatic aberration

Chapter Two

Frame & Face Measurements

Frame measurement and marking

Datum system:

The datum system for measuring lenses was established as a system of reference points for frames and lenses to facilitate accurate placement of lens optical centers and bifocal segment heights.

With the lens placed as it should sit in the frame, horizontal lines tangent to the highest and lowest edges of the lens are drawn.

- A line drawn halfway between the two horizontal lines and parallel to them becomes a reference and is known as ***datum line.***
- The width of the lens along this line is known as the ***datum length*** or ***eyesize.***
- The point along the datum line halfway between the edges of the lens is known as the ***datum center.***
- The depth of the lens, measured as the vertical depth through the datum center, is the ***mid-datum depth.***

Boxing system:

Boxing system is improved on the foundation provided by the datum system by adding vertical lines paralleling each other and tangent to either side of the lens, thus forming a box around the lens.

• ***Geometrical center:***

The center of the lens becomes the point on the datum line halfway between the two vertical lines.

• ***Size:***

- Is the length and depth of the box containing the lens.
- The horizontal length is now commonly referred to as the eyesize when referring to the frame, and the lens size when referring to the lenses (measured in millimeters).
- When most practitioners speak about lens size or eyesize, they are referring primarily to the horizontal measure of the lens.

- ***Measurements:***

In determining the horizontal dimensions of a frame, the measurement begins at the inside of the groove on one side and extends across the lens opening to the farther part of the groove on the other side.

The groove on the inside of the frame eyewire holds the lens securely in place.

In measuring the lens, the measurement begins at the apex of the bevel on one side of the lens and extends to the apex of the opposite side.

(the edge of a lens is usually beveled or grounded into a **V** shape so that it will fit securely into the groove of the eyewire).

1. Effective diameter (ED):

- It is found by doubling the distance from the geometrical center of the lens to the farthest apex of the lens bevel.
- This measurement helps determine the smallest lens blank from which the lens can be cut.

2. Frame difference (lens difference):

- The difference between the horizontal and the vertical measurements.
- It is measured in millimeters.
- The larger the difference, the more rectangular the enclosing box appears.

3. Distance between lenses (bridge size) DBL:

- Is the distance between the two boxes when both lenses are boxed off in the frame.
- Measured on the frame as the distance from the inside nasal eyewire grooves across the bridge area at the narrowest point.
- Measured in millimeters.

4. Geometrical center distance (GCD):

- The distance between the two geometrical centers of the lenses.

- Measured from the left side of one box to the left side of the other box (it can be calculated by simply adding the eyesize to the DBL)
- GCD also known as distance between centers (DBC).
- The term frame PD is commonly used in dispensing, but it has no relationship to IPD. It may have originated when frame size was determined by selecting the correctly fitting bridge size, then choosing an eyesize so that the wearer's pupils would be at the geometric centers of the frame.

5. Segment height:

(In bifocal or multifocal)

- When specifying segment height, the reference point are given (in millimetres) as either:

  (1) Segment drop or segment raise: the distance below or above the datum line.

  (2) Segment height: the distance from the lower line of the boxing system rectangle enclosing the lens shape.

  In actual measuring process, the level of the lower line of the box corresponds to the lowest point in the eyewire groove.

  The level may be different from the depth of the point on the lens edge found directly below the pupil.

Temple length

- Most temples are currently marked with the total temple length.
- Temple length is measured in millimetres.
- Temple length may be measured in one of the following ways:

  1. Overall temple length:

  when measuring the overall length, it is necessary to measure around the bend and not in a straight line, unless the temple is straight.

  Comfort cable temples are measured in terms of overall length. The actual measurement is done. By grasping the tip and extending the temple along the ruler.

- Measured in millimetres.
- When converting from an old temple length in inches to millimeter length. Either multiply inches by (25.4).

2. Length to bend (LTB):
   - An older method of measuring temple length.
   - Measured from the center of the barrel to the middle of the bend.
   - Length of drop: the distance from the middle of the temple bend to the end of the temple.

3. Front to bend (FTB):

   If the endpieces wrap around in a swep-back manner, there is a distance between the plane of the frame front and the actual beginning of the temple.
   - It would be slightly longer than LTB.

Frame Markings

Most frames are now marked according to size, giving:

1. Eyesize.
2. Distance between lenses.
3. Temple length.

- Eyesize and DBL:
  - When a frame marking such as (50 □ 20), it means that the eyesize is 50 mm and DBL is 20 mm.
  - The box between numbers means that the eyesize measured according the boxing system, it also surves to separate the two numbers.
- Location of markings:
  - ***On plastic frame:*** the marking may be found in any of several places.

    Some frames have the size printed on the back side of the endpiece.

    Sometimes the eyesize is printed on one endpiece and the DBL on the other.

Temple length is printed on the inner side of the temples.

Sometimes all the three measurements on the temple.

- ***On metal frame:*** the eyesize and DBL are usually on the inside of the bridge, although occasionally they are printed on the underside of a top reinforcing bar.

• Frame manufacturer Name, Color, Country of Origin:

Many frame manufacturers use a number rather than a name. This can be confusing if the frame color is also specified by number and both numbers are stamped on the frame. Consulting a frame reference catalog will help.

Face measurements and frame selection

Finding eyeglasses frames that fit the patient's face:

To choose the best frame you must check 3 things:

1. Make sure eyes are centered in the frame. This is the most important factor in choosing a frame especially with strong prescriptions and progressive lenses. Regardless of lens material, if the eye is properly centered, the lenses will come out thinner. (least amount of decentration = less lens edge thickness).

This is achieved by:

- Measuring interpupillary distance (IPD):

The first step in design and ordering of eyewear for a patient is the measurement of the patient's PD. Both distance PD and near PD are measured.

Distance PD:

To measure distance PD, the examiner faces the patient at a distance of approximately 40 cm and holds a millimeter ruler in the patient's spectacle plane. The patient is instructed to look at the examiner's left eye, and the examiner aligns the temporal edge of the patient's right pupil with the zero in the scale of the millimeter ruler. He then instructs the patient to look at his right eye, and notes the millimeter reading which is aligned with the nasal edge of the patient's left pupil.

For patients having dark iris, it is usually necessary to align the scale reading on the millimeter ruler with the temporal limbus (corneoscleral junction) of the right eye and the nasal limbus of the left eye.

Near PD:

When the patient accommodate for near vision he also converge so the near PD is shorter than distance PD.

In measuring the near PD, the examiner again faces the patient at a distance of approximately 40 cm and instructs the patient to fixate his right or left eye, the tip of his nose, or other near target. The examiner aligns the temporal edge of the patient's right pupil with the zero on the scale, and notes the scale reading corresponding to the nasal edge of the left pupil. For 40 cm distance, the near PD is usually about 4 mm less than that of the distance PD.

2. Assess size of nose to see if a large or narrow bridge is best:

   Most weight of the spectacle is borne by the nose when the head is held in an erect position. To prevent irritation of the nose, the bridge of the frame distribute the weight of the spectacles over as large an area as possible.

   Use large bridge for wide noses or a narrow bridge (generally with nose bad) for narrow noses to ensure proper fit.

   A narrow/small frame bridge on a large nose will push the frame up on the face and prevent the wearer from looking through the centers of the lenses, cause terrible marks on the nose and look horrible.

   Small or arrow noses require small bridges. If a frame bridge is too large for a nose it will leave a horrible mark on the top of a person's bridge. If it is metal it could even cut the skin.

3. Make sure temples are long enough so that they can be adjusted properly:

   As the head tilted forward, the weight of the spectacles shifts from the nose to the ears.

   Short temples look horrible and will cause unwanted tilt and thus alter the way one sees through their glasses.

The best frame characteristics:

1. It should not be higher than the eyebrows
2. It should not compress on the nose
3. It should not compress on the temple
4. It should not compress on the cheeks
5. It should not interact with the skin secretions

Common maladjustments and their remedies:

Condition	Possible causes	Remedy
Pads dig into nose evenly	Pads too tight	Use larger pads
Spectacle slides down on nose	Distance between pads too great	Bring pads closer together
Lashes touch lenses	Distance between pads too great	Bring pads closer together Use deeply curved lenses
One lens higher than another	Unequal pantoscopic angle. Deformed nose	Adjust pantoscopic angle Adjust to balance

Different faces shapes:

There are seven basic face shapes: oval, round, heart, rectangular, triangle, square and diamond.

You should select frames that offset the shape of the face with the frame. For example, instead of a round frame o a round face, select an angular or rectangular frame.

The following are general guidelines for identifying face shape and choosing appropriate styles:

- **Oval:** top and bottom of face are well balanced; suggest any style except extreme geometric designs.
- **Round:** large curved forehead and rounded chin, face is full without angles; suggest square or angular frames.
- **Heart:** forehead is widest part of face that narrows gradually to slightly pointed chin; suggest rimless design.

- **Rectangular:** long narrow face; bigger, longer frames are more appropriate if you want to make your face appear shorter.
- **Triangle:** narrow head, face gradually becomes fuller at cheeks and chin; suggest rimless designs.
- **Square:** wide forehead cheeks and chin, oval or round glasses will contrast with your face to de-emphasize its squareness.
- **Diamond:** small forehead, wide temple that gradually decreases to a small chin area; suggest oval or avoid angular.

Chapter Three
Optical Lenses

The Optical Lenses

Definition:

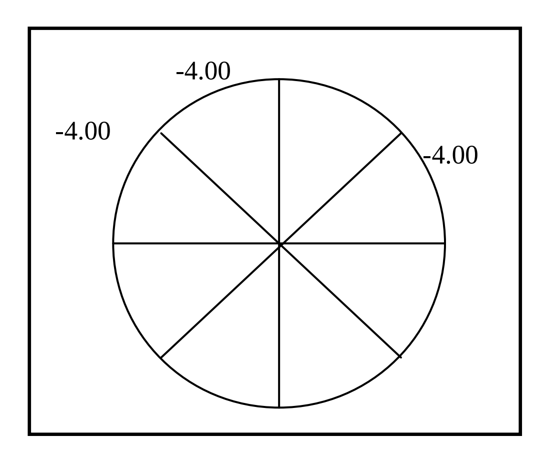
A transparent component made from optical quality materials and curved to converge or diverge rays come from an object.

Types of lenses:

1. Spherical lenses.
2. Cylindrical lenses.
3. Toric lenses.

Spherical lenses

- Lenses that have the same power on all directions. (It is a part of a sphere)
- Used in correcting simple refractive errors (Myopia, hypermetropia)



The spherical lenses are divided into two types:

1. Convex lenses (plus lenses):

A lens that converge the parallel light comes from an object to a focal point that is behind the lens.

The image will be real.

2. Concave lenses (minus lenses):

A lens that diverge the parallel rays comes from an object to a focal point that is in front of the lens.

Create a virtual image.

Forms of sphere lenses:

1. Plano convex: one surface is Plano and the other is convex.
2. Plano concave: one surface is Plano and the other is concave.
3. Bi-convex: both surfaces are convex.
4. Bi-concave: both surfaces are concave.
5. Equi-convex: both surfaces are convex in case if both curvatures are equal.
6. Equi-concave: both surfaces are concave in case if both curvatures are equal.
7. Convex meniscus: when the convex surface will be more than the concave.
   - Pereoscopic meniscus: concave surface usually -1.25
   - Deep meniscus: concave surface usually -6.00
8. Concave meniscus: when the concave surface will be more than the convex.
   - Pereoscopic meniscus: convex surface usually +1.25
   - Deep meniscus: convex surface usually +6.00

Cylindrical lenses

- The curved surfaces forms a part of cylinder lens and the diopteric power on all axes positions is not the same.
- After passing the lens, the light beam focuses into a straight line (or a broken line).
- A cylinder lens has power only in one axis.
- A cylinder lens is a small piece of the outer portion of a cylinder.
- Cylinder lenses have plus or minus curvature in one direction, with the axis in the other direction.

- If cylinder lens is prescribed, it must be designated as plus or minus and also the axis of the cylinder must be stated (e.g. -0.50X90 or +0.50X90).
- Many lenses are prescribed with the sphere and the cylinder in the same lens called compound lenses (e.g. +1.00+0.50X90).
- They differ from spherical lenses in that they focus a beam to a focal line rather than a focal point.

The Sphero-cylindrical lens is divided into two types:

1. Sphero-cylindrical lens with plus cylinder:

e.g. +1.00 / +2.00 × 90

2. Sphero-cylindrical lens with minus cylinder:

e.g. +1.00 / -2.00 × 180

Toric lenses

Cylinder lens forms:

Even a pure cylinder may take several forms. These forms are limited only in that one meridian have a net power of zero and the other a net power equal to the cylinder value. To keep the two meridians of a cylinder separate, it is helpful to use the concept of a power cross. A power cross is a schematic representation of the two major meridians of a lens surface. For a pure cylinder these two meridians, at right angles to each other, are the axis meridian and the power meridian.

A +4.00X90 cylinder lens has two front curves, a Plano curve in the 90 degree meridian and a +4.00 D curve in the 180 degree meridian. The back surface is Plano in both meridians and is flat. In this lens form, since the back surface has zero power, the front surface creates the total power of the lens.

Suppose, however, that the back surface of the lens had a power of -2.00 D in both meridians. It is still possible to construct a cylinder lens with the same total power given these circumstances.

If for example, the front surface powers are F_1 at 90= +2.00 D and F_1 at 180= +6.00 D with the back surface power F_2= -2.00 D, the total

lens power is still +4.00X90. Both 90 degree surface meridians are added together to obtain the total lens power in the 90 degree meridian, and both 180 degree meridians are added together to obtain the total lens power in the 180 degree meridian.

When a lens has two separate curves on a surface, neither being Plano but both having power, the surface is said to be ***toric.***

When the lens obtains its cylinder power from a difference in power between two front surface meridians, the lens is said to be ground in plus cylinder form. If, on the other hand, a lens has a cylinder component but the cylinder power is a result of a difference in power between two back surface meridians, it is a minus cylinder form lens. In other words, the plus cylinder lens has two curves on the front and one spherical curve on the back, whereas a minus cylinder lens has one spherical curve on the front and two curves making up the cylinder component on the back.

Minus cylinder form:

Just as with a sphere or a cylinder, a Sphero-cylinder combination may also be constructed in several different forms so as to give the same total power (F_t). For example, a lens has a spherical front surface power (F_1) of +3.00 D and a cylindrical back surface where F_2 at 90 equals 0 and F_2 at 180= -2.00 D. It is almost immediately obvious that when this lens is written as a prescription, the sphere power will be = +3.00 D and the cylinder power -2.00X90. This becomes apparent because the lens form is constructed as if a Plano convex sphere lens of +3.00 D front surface power with a flat back surface were placed flush against the flat front surface of a Plano minus cylinder lens. In abbreviated form, the Sphero-cylinder combination is written +3.00-2.00X90.

The best method to find the total power of the lens is to enter the data on power crosses.

Power can be interpreted from information given on a power cross as follows. If the prescription is to be written in minus cylinder form, the greater plus (or least minus) value is established as the sphere, since the cyl value is the difference between the two values, and the axis value is the axis of the 2^{nd} number (cyl value).

Plus cylinder form:

A lens may be constructed such that the front surface is toric and the back surface is spherical. Because the lens will be meniscus in form with the cylinder value on the front, the lens is plus cylinder lens. It may well have the same total power as a lens constructed in minus cylinder form.

Transposition

The written plus cylinder lens prescription would be used exclusively for lenses with a toric front surface and the written minus cylinder prescription for toric back surface lenses.

Because written lens prescriptions may be written in either plus or minus cylinder form, it is necessary to be able to convert or transpose from one form to another. This process is known as toric transposition.

Steps:

1. Add the sphere and cylinder values to obtain the new sphere value.
2. Change the sign of the cylinder.
3. Change the axis by 90 degree (this can be done by addition or subtraction 90 degree).

Base curves (single-vision lenses):

- In constructing an ophthalmic lens, one of the lens curves of one surface becomes the base from which the others are determined. This beginning curve, on which the net lens power is based, is called the ***base curve.***
- In the case of spherical lenses, the front sphere is the base curve.
- If the lens is plus cylinder form, there are two curves on the front:
  - The base curve is the flatter of the two curves.
  - The other curve becomes the cross curve.
  - The back surface referred to as the sphere curve.
- If a lens is in minus cylinder form:
  - The front spherical curve is the base curve.

- The weaker back-surface curve is known as the toric base curve.
- The stronger back-surface curve is known as the cross curve.

Designing a Lens to Change the Appearance of the Eye

Normally, lens power is used only to correct refractive error, and prism power to alleviate problems with binocular vision. Yet, there is another use for power, prism, and even tint that has nothing to do with refractive error: it can also be used to improve the cosmetic appearance of a blind or prosthetic (artificial eye).

Changing the apparent size of the eye:

Lenses have the optical effect of magnifying if they are plus or minifying if they are minus. When a plus lens magnifies it not only causes the world to look larger to the wearer, but the wearer's eyes will also look bigger to everyone else. Normally, dispensers try to reduce this effect by using aspherics to flatten and thin the lens. Yet, sometimes it may be advantageous to make a nonseeing eye look bigger.

• *Using spheres:*

If a person has lost an eye and had it replaced with a prosthetic eye, the artificial eye may match the color of the Seeing Eye perfectly, however the artificial eye may have a smaller appearance, To correct this effect, hold up plus trial lenses in front of the prosthetic eye until it looks closer in size to the seeing eye. When a good match is achieved, use the experimentally found power. Likewise, if the nonseeing eye looks too big, minus power can be used to make it appear smaller.

• *Using cylinders:*

Plano cylinders may be used to change only the horizontal or only the vertical size of the eye. For instance, sometimes even when the horizontal dimension of the eye looks normal, the vertical depth of the palpebral fissure of the non seeing eye may be smaller than that of the seeing eye. To make the fissure look larger vertically, a plus cylinder axis 180 may be used. To find the correct power, hold plus cylinders up in front of the eye until the desired cosmetic effect is achieved.

• *Tilting the cylinder to change lid slant:*

Some times, the eyelids of the prosthetic eye may appear slanted. When a cylinder lens is rotated on its axis, it will cause a horizontal line to tilt. A plus cylinder will cause a straight line to tilt against the direction of rotation, whereas a minus cylinder will cause a line to tilt with the direction of rotation. When deciding whether to use plus or minus cylinder, the deciding factor is magnification.

To determine the optimum axis placement, hold the cylinder lens in front of the eye (using trial frame) and turn the axis until the slanted lids match the straight lids.

Summary

1. The apparent overall size of the eye may be changed using plus or minus sphere lenses.
2. By using plano cylinder lenses, the size of the eye may be increased in one meridian (the power meridian of the cylinder). The magnification in the meridian 90 degree away (the axis meridian) will remain unaffected.
3. Rotating a plano cylinder lens away from the horizontal or vertical meridian causes tilt. If eyelids look unnaturally tiled, place a cylinder lens in front of the nonseeing eye and rotate the cylinder axis until the eyelid looks more like the seeing eye.

Using a lens to camouflage scars or deformities:

Sometimes a nonseeing eye is scarred or disfigured. In this case, a lens should be selected that will decrease the visibility of the eye. Tinting may be applied to the lens as either a solid or a gradient tint. Keep in mind that tinting both lenses will decrease the wearer's vision at night. Cosmetic consideration should not rule over safety considerations.

Changing the apparent location of an eye:

Trauma causing the loss of an eye can also cause the displacement of the socket. This makes the prosthetic eye appear higher or lower than the seeing eye. If the blind or prosthetic eye is lower or higher or appears to turn inward or outward compared with the seeing eye, its apparent location may be altered by using prism.

The base direction of the prism used will always be in the direction of displacement. In other words, if the eye appears too high, use base up prism. If the eye turns in, use base in. The wearer's eye will appear to be displaced toward the apex of the prism. Such prism is called inverse prism because it is opposite to what would normally be prescribed for a seeing eye.

This table summarizes the use of lenses for cosmetic effects:

Problem	Desired cosmetic effect	Lens solution
Eye looks small.	Make the eye look bigger.	Use a plus sphere lens.
Eye looks large.	Make the eye look smaller.	Use a minus sphere lens.
Eye not opens as wide as the seeing eye. (Fissure looks too small vertically).	Widen the fissure vertically.	Use a plus cylinder, axis 180.
Eye open wider than the seeing eye. (Fissure looks too large vertically).	Close the eye somewhat.	Use a minus cylinder, axis 180.
Eye looks too low.	Raise the apparent height of the eye.	Use base down prism.
Eye looks too high.	Lower the apparent height of the eye.	Use base up prism.
Eyelid is slanted.	Cause the rotated appearance of the lid to change in tilt and match the horizontal look of the seeing eye.	Rotate plus cylinder axis against the direction of desired tilt, or rotate minus cylinder axis with the direction of desired tilt.
Eye has unsightly appearance or scarring of the lids or orbital area.	Reduce visibility of the eye.	Use tinted glasses-solid tint for overall masking, gradient tint to mask the upper areas.

Chapter Four
Measurements of Lens Curvature

Measurement of lens curvature

The lens measure (lens clock):

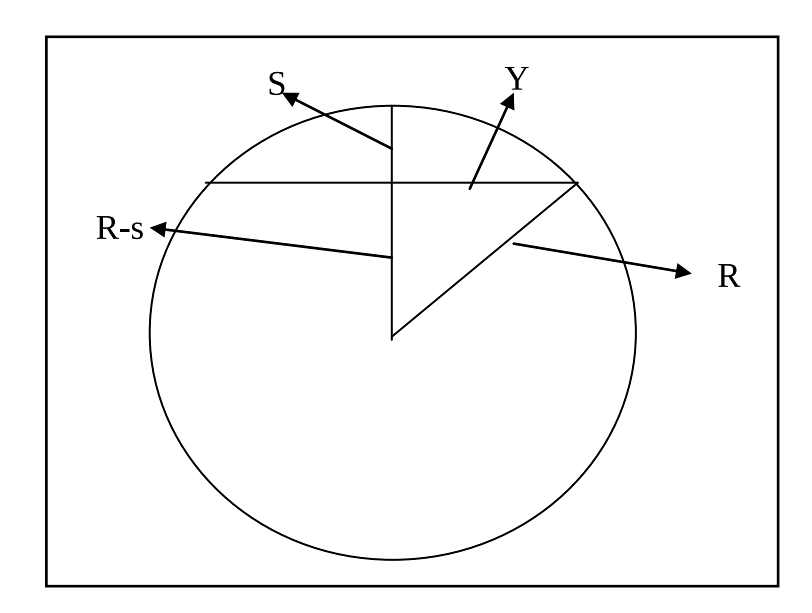
- Operates on the principle of the sagittal depth (sag) formula.
- Sagittal depth:

  Is the height or depth of a given segment of a circle.

  If it is known, the surface power may be calculated.
- The lens measure has 3 legs (points of contact with the surface), the outer two are stable, and the center leg moves in or out.
- The vertical difference between the position of the two outer contact points in reference to the position of the center contact point is the sagittal depth for the arc of a circle.
- A lens measure has an outer minus scale for concave surfaces and an inner plus scale for convex surfaces.
- A lens measure calibrated for glass lenses of n= 1.530.

The sagittal depth formula:

- To find the diopteric value for a lens surface, we need to know **r** (the radius of curvature).



- The rectangle has a relationship between its three sides that can be written as:

$$r^2 = (r-s)^2 + y^2$$

$$r^2 = r^2 - 2rs + s^2 + y^2$$

$$2rs = s^2 + y^2$$

$$r = s/2 + y^2/2s$$

- Once **r** is determined using the **sag** formula, then the formula for surface power may be used to solve for F_1 and F_2.

$$F = (n_2 - n_1)/r$$

Example:

A certain lens of index 1.523 has a convex spherical front surface. The sagittal depth of the front surface is 1 mm for a chord whose length is 20 mm. What is the power of the front surface?

$$Y = \text{chord length}/2$$

$$= 20/2 = 10 \text{ cm}$$

$$S = 1 \text{ mm}$$

$$R = y^2/2s + s/2$$

$$= 100/2 + ½$$

$$= 50.50 \text{ mm}$$

$$F_1 = 10.36 \text{ D}$$

Using the lens measure to find the nominal power of the lens:

- Because it is possible to measure lens surface values directly for conventional crown glass lenses using a lens measure, it is also possible to use a lens measure for finding the nominal power of a lens.
- Not all the lenses are spherical, however, making it necessary to check more than one meridian for differences in power. This is

done by holding the lens measure such that the center contact point of the lens clock is at the optical center and the lens clock is perpendicular to the lens surface.

The lens clock is rotated on this point with all 3 legs against the lens.

- If the indicator on the lens clock dial remains stationary, the surface is spherical.
- If the indicator shows a changing value, the surface is toric, with two separate curves.
- The value of these curves are indicated when the lens clock shows its maximum and minimum values.
- The orientation of the three legs on the lens at maximum and minimum readings corresponds to the meridians of lens power.

Example:

When rotating the lens clock on the front surface of a lens it is found that if the three contact points are horizontally aligned exactly along the 180 degree meridian, a maximal value of +7.50 D is found. When the three contact points are oriented in the vertical 90 degree meridian, a minimal value of +6.00 D is found. If the back surface reads -5.00 D in all meridians what is the power of the lens?

By drawing it on the cross axis, the total lens power could be written in one of three possible forms:

- +1.00 +1.50 X90
- +2.50 -1.50 X180
- +1.00X180 / +2.50X180

Apparent motion

- If an object is viewed through a moving plus lens, the object will appear to move in the opposite direction from the direction of movement of the lens. This is termed “against motion“.
- If an object is viewed through a minus lens, the object will appear to move in the same direction as the movement of the lens. This is termed “with motion”.

Neutralizing a lens with trial lenses:

- This phenomenon can be used to identify the sign and approximate power of a lens without the use of a lensmeter. The power can be estimated by holding a trial lens against the unknown lens and observing apparent motion.
- The power of the trial lens is changed until there is no apparent motion detected.
- The power of the unknown lens is equal in dioptre value and opposite in sign to the trial lens.
- This method can be used to approximate the lens power of a sphero-cylinder by moving the lens along different axis lines.
- The axis of the sphero-cylinder is 90 degree from the line that provides the most dioptre power.

Neutralizing a cylindrical lens:

- Cylinder lenses cause the background (optical cross) to look slanted.
- If we observe a line viewed through a cylindrical lens the line will appear to move with the direction of rotation along the (+) cyl axis and against the direction of rotation for a minus cyl axis.
- The lens should be rotated till the two meridians in the lens are superimposed with the two meridians of the background (optical cross)
- Then one power is neutralized by moving the lens vertically, the other by moving the lens horizontally.

Lensmeter (lensometer)

A lensmeter is an instrument used to measure the power of an existing lens. An optician uses a lensmeter to determine the prescription of a patient's eyeglasses.

The lensmeter is one of the more used optical instruments in the ophthalmology field. This is a device used for checking eyeglass lenses to make sure they are the right prescription. It can check the sphere, cylinder, or axis of a lens.

The parts of this ophthalmic equipment are:

- The Eyepiece; which is just like the eyepiece on a microscope.
- The Marking Device, which is used to mark a lens with a water soluble marker.
- The Lens Stop; for holding the lens in place.
- The Aperture; this lets light through to the lens.
- The Spectacle Table; eyeglass frames rest here.
- The Power Scale; which is a dial on the side that lets you check to see what power the lens is.
- The Axis Drum; which you use to check to see what the axis of the lens is.
- The Power Switch.

If you look into the lensmeter you will see three lines bisected by two thinner lines. When a lens is placed in front of the aperture it will blur these lines.

When it is adjusted to the correct RX the lines will no longer blur.

Ideally when you check the lens against its prescription it should match up to the readings of the lensmeter.

If that is not the case then the lens are defective and need to be remade. At any optical retail store with ophthalmic instruments this equipment is used to check glasses before they are issued to the customer. This is done whether or not the store has an on-site lab.



Manual lensmeter



Automated lensmeter

How to find single-vision lens powers using a crossed-line-target lensmeter:

- Begin by focusing the eyepiece to ensure an accurate reading (looking at the crosshairs and concentric circles, not the crossed-line illuminated target, slowly turn the eyepiece until the crosshairs and concentric circles come into sharp focus).

  When more than one person uses the lensmeter, the procedure must be repeated for each individual.

- Place the lens in the lensmeter so that the back side of the lens is against the lensmeter aperture.

- If the prescription is a sphere:

  The illuminated target will clear all at once.

- If the prescription contains a cylinder component, the sphere and cylinder lines will not focus simultaneously.

- If the prescription is cylinder:

  There are two ways to read or write a prescription, one is to read the cylinder in the prescription as a minus cylinder, the other is in plus cylinder.

- Minus cylinder:

  1. Begin by turning the power wheel in the high plus direction until the sphere lines will begin to clear.

  2. If the sphere lines begin to focus first but cannot fully cleared, turn the axis wheel until the sphere lines do clear.

  3. Slowly turn the wheel back in the minus direction until the cylinder lines will be clear.

- Plus cylinder:
  1. Slowly turn the wheel in the minus direction (or in the less plus direction) until the sphere lines will begin to clear.
  2. If the sphere lines begin to focus first but cannot fully cleared, turn the axis wheel until the sphere lines do clear.
  3. Begin by turning the power wheel in the high plus direction until the cylinder lines will be clear.
- How to record the prescription from the lensmeter:
  1. When the sphere lines appear clear and unbroken, record the value shown on the power wheel as the sphere power of the prescription.
  2. When the sphere lines become blur and the cylinder lines become into focus (clear), the difference between the sphere reading and this new reading is the power of the cylinder.
  3. The value seen on the axis wheel is the cylinder axis.
- In older instrument the target may consist of a single line, which represents the sphere, crossed by three widely spaced lines, which represents the cylinder.

  A more common configuration consists of three closely spaced lines for the sphere, crossed by three widely spaced lines representing the cylinder.

Find and spot the optical center of the lens:

- After finding the sphere, the cylinder and the axis, locate the OC of the lens by centering the illuminated target at the intersection of the crosshairs in the eyepiece (this is done by moving the glasses left or right, up or down on the instrument table)

  Once centered, the lens is spotted using the lensmeter spotting mechanism.

Chapter Five
Back Vertex
Power & Distance

Front and back vertex powers

It has been shown that because of lens thickness, the nominal power of a lens doesn't accurately predict the real power of the lens. It will be recalled that when parallel light enters the front of a lens, it is refracted and exists from the rear surface of the lens. The image falls at the second principal focus.

The reciprocal of the distance in air from the rear surface of the lens to the second principal focus is a specific measure of the power of this lens and is known as the back vertex power (F_v'). (This is the measure of power of most importance in ophthalmic lenses).

Also, in review, if parallel light enters from the rear surface, the place where the image now forms is known as the first principal focus. The reciprocal of the distance in air from the front surface to the first principal focus is another measure of the power of the lens and is referred to as the front vertex power (F_v). It is not unusual to find front and back vertex powers to be different. If the lens is equiconcave or equiconvex, the front and back vertex powers will be the same. If the lens has any other form and is thick, there may be a measurable difference between the two.

Calculating front and back vertex powers:

Front and back vertex powers may be found by finding vergences as light approaches and leaves each lens surface. They may also be found using a formula summarizing the necessary vergence factors. Following the vergence methods introduced earlier for solving this type of problem will give a much better understanding of the action of a lens on light than will simple formula memorization. Both methods are presented.

Solving for front and back vertex powers using vergences:

If light enters a lens as parallel rays, the back vertex power of a lens will be equal to the vergence these light rays have when leaving the lens. If the form, thickness, and refractive index of that lens are known, the back vertex power may be found by systematically tracing the path light rays take through the lens.

Solving for front and back vertex powers using formulas:

The previous vergence methods may be summarized into formulas. The formula for back vertex power is

$$F_v' = [F_1 / (1 - (t/n) F_1)] + F_2$$

And that for front vertex power is

$$F_v = [F_2 / (1 - (t/n) F_2)] + F_1$$

The above formulas give results that are accurate and identical to those found by the vergence method. Alternate formulas for F_v and F_v' derived from the above formulas using higher mathematics are

$$F_v' = F_1 + F_2 + t/n\,(F_1)^2$$

And

$$F_v = F_1 + F_2 + t/n\,(F_2)^2$$

These formulas are approximations and, although somewhat easier to work, are not expected to give the accuracy of the more exact forms. The approximations were more widely used before small calculators became available.

Example:

If a lens has dimensions of $F_1 = +8.00$ D, $F_2 = -2.00$ D, t= 5 mm, and n= 1.523, what is the back vertex power of the lens?

Solution:

Light entering the lens must be from an object at infinity to determine back vertex lens power accurately. The rays entering the front surface of the lens will then be parallel, having a vergence of zero. Since

$$L_1' = F_1 + L_1$$

$$L_1 = 0.00 \text{ D}$$

$$L_1' = +8.00 + 0.00 = +8.00 \text{ D}$$

To find the vergence of light at F_2 the reduced thickness is subtracted from f_1:

$$l_2 = l_1' - t/n$$

$$l_2 = 1/8 - 0.005/1.523$$

$$l_2 = 0.1217 \text{ m}$$

Therefore, the vergence of light of F_2 is:

$$L_2 = 1/l_2 = 1/0.1217 = +8.22\ D$$

(this is the same procedure as finding the effective power of F_1 or F_2)

Now, since

$$L_2' = F_2 + L_2$$

$$L_2' = +6.22\ D$$

Solving the front and back surface powers using formulas:

The previous vergence methods may be summarized into formulas. The formula for back vertex power is:

$$F_v' = [F_1/\ (1\text{-}t/n\ {*}F_1)] + F_2$$

And that for front vertex power is:

$$F_v = [F_2/\ (1\text{-}t/n\ {*}F_2)] + F_1$$

Alternate formulas derived from the above formulas are:

$$F_v' = F_1 + F_2 + t/n\ (F_1)^2$$

And

$$F_v = F_1 + F_2 + t/n\ (F_2)^2$$

Back vertex distance

Vertex distance:

The distance between the back surface of a corrective lens (spectacles), and the front surface of the cornea.

Increasing or decreasing the vertex distance changes the optical properties of the system, by moving the focal point forward or backward, effectively changing the power of the lens relative to the eye. Since most refractions are performed at a vertex distance of 14mm, the power of a corrective device fitted at a different vertex distance may need to be compensated to effect the same correction of the initial refraction (note: refraction is portion of an eye exam that is performed with a phoropter).

Effect of changing the back Vertex distance:

Adjusting the distance either further from the eye or adjusting the lens nearer will change the effective power of the lens.

In the case of a minus or diverging lens, the further it is moved from the eye the weaker it becomes and the closer to the eye the stronger it becomes.

The opposite is true in the case of a convergent or plus lens. The further it is from the eye, the stronger it will be. As mentioned before weaker prescriptions will not be effected as much as those that are -4.00 diopters. Let¹s look at our example.

OD: -5.00 SPH

OS: -5.50 SPH

This patient comes in wearing glasses that are sitting 20mm away from the eye instead of 14mm, so what is the actual prescription? To determine this we need to use the vertex compensation formula:

$$Dc = \frac{D1}{(1 + d \times D1)}$$

Dc = Compensated Power

Dl= Original Lens Power

d= Change in Vertex Distance in Meters

For the right eye we have a spectacle power of -5.00 SPH sitting 6mm further from the eye than it should.

$$Dc = \frac{5.00}{(1 + .006 \times 5.00)}$$

$$Dc = \frac{5.00}{1.03} = 4.85$$

The new sphere power is -4.85. The best way to determine vertex distance is though the use of an instrument called a distometer. This device places one arm on the eye lid while the other is placed on the back of the lens, and a small scale attached to the device measures the distance. Now let¹s take a look and see what happens when tilt is added.

Pantoscopic angle:

Angle in the vertical plane between the optical axis of a spectacle lens and the visual axis of the eye in the primary position, usually taken to be the horizontal.

Effect of pantoscopic tilt:

Generally some pantoscopic tilt and face-form is desired but when these adjustments are made too drastically, they can affect the optical quality of the lens. Unlike vertex distance, these two adjustments create something called marginal astigmatism. This monochromatic aberration is the result of light passing obliquely through the lens, creating two focal points much like a toric lens designed for those with astigmatism. Flat base curves and excessive tilt are the major causes of this. Let's look at what happens to the above prescription when the pantoscopic tilt is changed from 14° to 22°.

$$Fns = -(1 + \frac{\sin^2 22^\circ}{2n})Fsph$$

Fns = New Sphere Power

n = Index of Refraction (In this case 1.498)

Fsph = Sphere Power

$$Fns = -(1 + \frac{0.1369}{2.244}) - 4.85$$

Fns = -5.15

Now we determine the cylinder power. Remember that face form will have its astigmatic error in the 90° meridian, while pantoscopic tilt will have it in the 180° meridian.

Cyl = - 4.85 × $\tan^2$ 22°

.08 dipoters of cyl. @ 180

Acutal RX is -5.15 - .08 × 180

Chapter Six
Prisms

Prisms

- A prism has the property of changing the direction of a beam of incident light without changing the vergence of the light.
- It is sometimes necessary to incorporate a prismatic component in the lens to compensate for an anomaly of binocular vision.

Prism:

A refracting medium bordered by two plane surfaces inclined at an angle.

- ***Prism angle (x):*** the angle formed by the two surfaces as they join at the apex.
- ***Base:*** the surface opposite the angle.
- ***Apex:*** the line at which the two surfaces join.
- ***Axis:*** a line bisecting the angle.
- ***Angle of deviation (D):*** the angle that a ray of light is deviated as it passes through a prism.
  - Rays of light are always deviated toward the base of the prism; the object appears to be displaced toward the apex of the prism.

Prisms are prescribed according to their power and the direction of the base. That is:

- Base up (BU)
- Base down (BD)
- Base out (BO)
- Base in (BI)

Or at an angle (<) base 15^o.

Angle of deviation affected by:

1. Refractive index of the prism.
2. Angle of the prism.
3. Angle of incident ray.

Angle of minimum deviation:

- That angle where the light passing through a prism is least deviated.
- Occurs when the angle of incidence equals the angle of emergence.
- For a prism of index (n) the angle of deviation is D according the formula:

$$D = (n-1)\ x$$

D: angle of deviation

N: refractive index

x: apical angle

- Image properties:

Erect, virtual, and displaced toward the apex of the prism.

Prism dioptre:

Unit of power of a prism that displaces light 1 cm at 1 m distance.

Angle of apparent deviation:

The apparent deviation of an object measured by the angle formed between the line of sight without the prism in place and the line of sight with the prism in place.

Centrad:

Unit of power that displace light one cm along an arc whose radius is 1 m and center is at the prism considered.

Methods of providing prismatic power in an ophthalmic lens:

1. Grind the prism into the lens during the surfacing process.
2. Decenter the lens.

Effects of prisms on movements of the eye:

The effect of prisms on movements of the eyes may be considered in terms of either **monocular** or **binocular** effects, and binocular effects may be considered in terms of **resultant horizontal prismatic effects** or in terms of **resultant vertical prismatic effects.**

Monocular prismatic effects:

If one looks at a distant object with one eye occluded while a prism is introduced before the eye, the image of the object is displaced toward the apex of the prism.

To look at the image of the object, a person's eye must move through an angle equal to the angle of deviation of the prism. Base in prism causes the eye to move outward (abduction), and base out prism causes the eye to move inward (adduction).

Binocular prismatic effects:

If, with both eyes open, one looks at distance object while a base in prism is placed before the right eye and a base out prism of equal amount is placed before the left eye, to look at the object both eyes move to the right by an equal amount.

• Conjugate movement or version movement:

The movement of the eyes in which both eyes move in the same direction and of an equal amount.

If a small amount of base out prism is placed before each eye, to see a single image, both eyes move inward by the same amount.

If base in prism is placed before each eye, to see a single image, causes the eyes to move outward.

• Disjunctive movement or vergence movement:

Eye movement in which the eyes move toward one another (convergence) or away from one another (divergence).

If prism bring about only conjugate movements, the resultant prismatic effect is considered to be equal to zero.

If prisms cause vergence movement, the resultant prismatic effect is the extent of the disjunctive movement.

Resultant horizontal prismatic effects:

1. When prisms are placed before each eye with their bases in the same direction for each eye (both base in or both base out): the resultant prismatic effects can be found by adding the powers of the prisms (base in added to base in, or base out added to base out).

2. If the bases are in opposite directions but of different powers the power of the weaker prism is subtracted from the stronger prism, and the remainder is the resultant prismatic effect.

Resultant vertical prismatic effects:

1. When vertical prisms are placed before each eye with their bases in the same directions for each eye but of different powers, the resultant vertical prismatic effect is found by subtracting the power of the weaker prism from that of the stronger. The base is expressed as applying to the eye with stronger prism.
2. If the bases are in the opposite directions, the resultant vertical prismatic effect is found by adding the powers of the two prisms. Since a base up effect of one eye is the same as base down effect in the other eye, the prismatic effect may be expressed with respect to either eye.

Prentice's rule:

$$P = d_{cm} \times F_v$$

P= the prismatic power in prism diopters.

d= the distance from the lens pole in cm.

F_v= the refracting power of the lens

Prentice's rule simply calculate the prismatic effect at any point on a spherical lens.

Determining the base direction:

The base of a prism can assume any position on a circle.

- Base in: the base of the prism is toward the nose (nasally).
- Base out: the base of the prism is toward the temporal side (temporally).

A circle for specifying the base of prism is often divided into four quadrants:

(For right eye)

- 0-90: the base is up and in.
- 90-180: up and out

• 180-270: down and out.

• 270-360: down and in.

(For left eye)

• 0-90: up and out.

• 90-180: up and in.

• 180-270: down and in.

• 270-360: down and out.

Horizontal and vertical component of oblique prisms:

Horizontal component, E_h= E cos (angle)

Vertical component, E_v= E sin (angle)

If both E_h and E_v are known, the prismatic effect can be found with use of the Pythagorean theorem:

$$E^2 = E_h^2 + E_v^2$$

Decentration:

The displacement of the pole of the lens from the geometric center is called Decentration.

A centered lens is one in which the pole falls at the geometric center; a decentered lens is one in which the pole is not located at the geometric center.

Lenses are decentered to control prismatic effects. Decentration is used both to create prismatic effects and to avoid prismatic effects.

Chpter Seven
Frame materials

Frame materials

Metal frames and mounting materials:

Commonly used metal frame and mounting materials are gold, aluminum, nickel silver, titanium, stanless steel, cobalt, monel and beryllium.

• ***Gold:***

Gold has many desirable attributes for a frame material:

1. It is easily worked
2. Corrosion resistant
3. Acid resistant
4. Does not tarnish readily
5. Can be alloyed with many other metals to change its color and strength.

Pure gold frames (24 karat) are too soft for frame making and are heavy and very expensive. Solid gold alloy frames, usually 18, 14 or 12 karat, are now rarely seen because they are expensive, but they are made by a small group of frame manufacturers.

The chemically pure, unalloyed metal is known as fine gold. Because a spectacle frame or mounting made of fine gold is too soft to be useful, other metals are added to improve the gold's hardness and durability.

Most metal frames and rimless or semi-rimless mountings with any appreciable gold content are categorized as gold-filled. The soaring cost of gold has made gold-filled stock materials a costly and risky investment, and fewer frame manufacturers hold stocks of this expensive product.

Gold-filled material consists of a base metal (usually special steel or copper alloy) to which a layer of gold has been bonded by the use of heat and pressure.

• ***Aluminum:***

Advantages:

1. It is stain and tarnish resistant
2. Durable
3. Light weight
4. It can be anodized to alter the surface to the oxide form, which is more resistant to corrosion.
5. It can be painted or colored in many attractive colors
6. It is strong and very rigid

Disadvantages:

1. Although the frames are durable in wear, their rigidity causes problems in fitting lenses to the frame and adjusting
2. It conducts heat readily and becomes especially cold in the winter

• ***Nickel silver (also called German silver):***

It has misleading name because the alloy contains no silver. It is composed of approximately 60% copper, 20% nickel, plus zinc and other materials.

The material is rigid and lustrous, but not very malleable. It is the metal of choice for the base metal is gold-filled frames.

• ***Titanium:***

Advantages:

It is a metallic element that is lightweight, flexible (easy to adjust), corrosion resistant, abrasion resistant, and has excellent memory retention.

Disadvantages:

It is expensive and the colors are limited.

• ***Stainless steel:***

It is a steel alloy containing 74% iron, 18% chromium, and 8% nickel.

Advantages:

It is durable, flexible, strong, and extremely resistant to oxidation and corrosion.

• ***Cobalt:***

With any alloy is the primary ingredient used for frames. The material is ductile and makes durable, flexible, lightweight, and resilient frames. The material is noncorrosive and takes many colors with a lustrous finish. It is relatively expensive.

• ***Monel:***

It is an alloy of 68% nickel, 30% copper, and 2% iron. It is corrosion resistant and can be coated with many colors. It is used mostly for temples and bridges because the eye wires are difficult to shape. It has a durable finish.

• ***Beryllium:***

It is a hard, light, metallic element used in an alloy with copper, nickel, and cobalt for frames. The frames are very light, strong, and resistant.

Plastic frame materials:

Plastic materials possess the following properties for producing frames that are relatively inexpensive, easy to adjust, and attractive:

1. Dimensional stability
2. Dermal stability
3. Colorfastness
4. Mechanical durability
5. Good strength-weight ratio
6. Good thermal-electrical insulation
7. High resistance to chemicals
8. Ease of production

There are two types of plastic materials: thermosetting and thermoplastic.

• ***Thermosetting materials:***

It begins as liquid and becomes solid during the manufacturing process because of the application of heat and pressure. Once the product has been manufactured, it never again softens to any significant extent, even at elevated temperatures or under pressure.

Examples of thermosetting plastics: melanines, phenolics, and polyesters.

• ***Thermoplastic materials:***

They have the property of softening when heated and hardening when cooled.

Examples of thermoplastics materials are: acrylics (including PMMA and polycarbonate)

Cellulose nitrate and cellulose acetate:

Although they are similar in appearance, but when used for spectacle frames they have very different properties.

Cellulose nitrate also called Zylonite is superior to cellulose acetate in the following respects:

1. It is tougher than cellulose acetate, and frames can be made thinner with it.
2. Its surface is harder, which allows it to take better polish to its surface.
3. It is easier to work because it can be stretched when heated and shrunk when cooled without measurable deterioration
4. Its softening point is higher than that of cellulose acetate and its water absorption, thus it has better dimensional stability in warm climates

In other hand cellulose acetate is superior to cellulose nitrate in three respects:

1. It can be produced faster than cellulose nitrate
2. Its frames are more colorfast than cellulose nitrate
3. Its frames are less combustible than cellulose nitrate frames

Although cellulose acetate frames can burn, but the propagation of flames is slow, frames made of cellulose nitrate are highly inflammable and so it has been banned for manufacturing.

• ***Acrylic:***

It is common name for the family of thermoplastic materials that includes polymethyl methacrylate, beside its usage in manufacturing for hard contact lenses, it is used in spectacle frames manufacturing, and it has many properties such as:

Dimensional stability, Colorfastness, Surface hardness, Lightness in weight and Flame resistance but it is brittleness and low impact resistance, and thus it is not often used for spectacle frames.

• ***Nylon:***

It is a generic name given to a class of thermoplastic polymers known as polymides.

It is tough and hard but it is limited by its brittleness, lack of transparency, poor color selection and high rate of water absorption. It is available but not often used.

• ***Optyl:***

It is a modified thermosetting material, its advantages are: hardness, noninflammability, dimensional stability, and lightness in weight.

Unlike traditional thermosetting materials, optyl becomes soft and pliable when heated above 87 C.

It has looked in chemical memory that is when reheated the frames return to its original shape.

It has the disadvantages that it must be heated to a higher temperature than needed for cellulose acetate, and the frame will break if an attempt to adjust when cooled.

• ***Polymide (co-polymide):***

It is a nylon blend that features durability, reduced weight and flexibility. And it is considered to be hypo allergic.

• ***Carbon fiber:***

Carbon and carbon fibers are added to frames to give them strength but keep them lightweight, they offer durability and shape retention.

Although many materials have been for the manufacture of plastic frames, most plastic frames are currently of the thermoplastic material cellulose acetate.

Chapter Eight
Bifocal lenses

Bifocal lenses

The Concept of a Near Addition:

When the crystalline lens within the eye becomes nonelastic as a result of the aging process, a person becomes unable to see clearly at close range, regardless of how well vision is corrected for distance. Addition of plus lens power to the distance correction is required to achieve clear vision at the near point.

If no distance correction is required, the only factor to be considered is the necessary plus lens power. If the wearer has a correction for distance, the required power must be "added on" to that already being worn. The near addition usually consists of a segment placed in the lower portion of the lens. For that reason, it is often referred to as the near segment, or in abbreviated form, the seg. The net power resulting from the combination of the add and the distance power is termed the near power, or near $R_{x.}$

The power of the near addition is written in prescription form as:

O.D. +1.00 D sph.

O.S. +1.25 D sph.

Add + 2.00 D

By this it is understood that both lenses are to contain a near segment whose power is 2.00 D more plus than the distance portion of the lens.

There are three types of multifocal lenses:

1. Bifocal lenses.
2. Trifocal lenses.
3. Progressive lenses.

• *Bifocal lenses:*

The term bifocal means literally "Two Focuses". It is meant to describe eyeglass lenses that enable the user to see clearly at two different distance ranges through one lens.

The biggest advantage of bifocal lenses is the convenience of not having to take your glasses on and off constantly

- There are four types of bifocal lenses:

• ***Franklin bifocal:***

Two lenses cut in half, and the two halves glued together.

Franklin’s bifocal lens was similar in appearance to the executive onepiece bifocal that is available today, a lens with a dividing line across its width.

These lenses have an excellent optical properties, since the portion for reading is large but it had two disadvantages:

1. The dividing line produced annoying reflections; it tends to collect dust and dirt.
2. The two portions can easily apart.

• ***Fused bifocal:***

It is available only in glass; the segment of the lens is made from glass having a high refractive index such as flint under high temperatures. A fused glass bifocal has no change of curvature.

The problem with this lens is the chromatic aberration; since the reading portion consists of two optical elements with different indices.

• ***Solid bifocal (One-piece) bifocal:***

These lenses are made from one lens material (glass or plastic). Any change in power in the segment portion of the lens is due to a change in the surface curvature of the lens. This type is good since there is no chromatic aberration and no difference in refractive indices.

One-piece bifocal can be identified by feeling the segment border: If a change in curvature is felt, the lens is a one-piece design, it is also called blended.

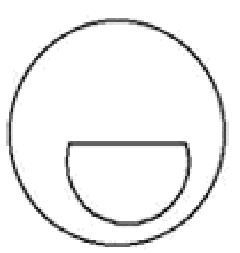
• ***Cemented bifocal:***

These lenses have a small segment glued onto the distance lens. Seldom used today, such lenses are usually in the form of small round segments. In these lenses the curvatures are different, while the refractive indices are the same.

Different segment shapes in Bifocal lenses:

The basic styles are:

1. Flat top bifocal:

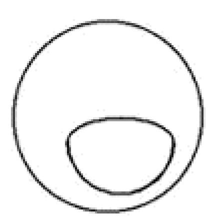


Flat-top segments are similar to round segments with the top cut off. The top is generally "cut off" 4.5-5.0 mm above the center of the segment. Stated another way, the segment OC is about 5 mm below the segment line. Flat tops are also known as D segments.

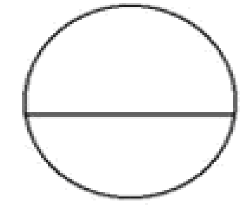
Segment sizes range from 22 mm up to 45 mm. Most lenses used now are 28 mm or greater.

2. Curve top bifocal:

Curve top segments look similar to flat tops, except that the upper line is arched, rather than flat. Panoptic segments are curved as well, but the corners are rounded.

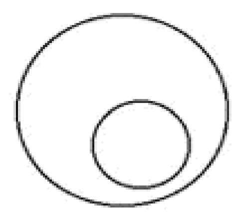


3. Excutive bifocal (E- line):



4. Round segment bifocal:

Round segments, vary in size from a small lens of 22 mm, up to the largest, 40 mm. The most common sizes are 22 and 38 mm. The optical center (OC) of the segment is always at the center of the segment.

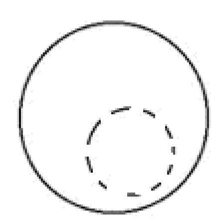


5. Ultex bifocal:

It is called also half moon.



6. Blended bifocal:



Blended bifocals are round-segment bifocals with the border smoothed out.

Segment dimensions:

1. Segment height (h):

The vertical distance between the segment top and the tangent line to the lowest point in the lens.

2. Datum line:

The line in the middle of the lens (divides the lens into two equal parts).

3. Segment depth(b):

The vertical distance between the top of the segment to the tangent line of the lowest point in the segment.

4. Segment inset:

The inward displacement of the segment optical center from the distance optical center, it is always in.

Segment inset is normally determined by measuring the distance and near PDs , and then insetting each of the segments one-half the difference between the distance and near PDs.

Total inset: the lateral displacement of the segment optical center from the geometric center of the lens.

E.g.: The frame size is 50 mm with a distance between lenses (DBL) 0f 18 mm, and the patient's distance PD is 64 mm and the near PD is 60 mm, what is the segment inset? The total inset?

The segment inset is (64-60)/2 = 2 mm in, for each lens.

The total inset = (68-60)/2= 4 mm in, for each lens (from the geometric center of the lens)

5. Segment diameter:

The diameter of the circle, in which the segment was taken.

6. Segment size:

It includes segment diameter and depth.

7. Segment drop:

The vertical distance between the datum line and the segment top.

8. Distance optical center:

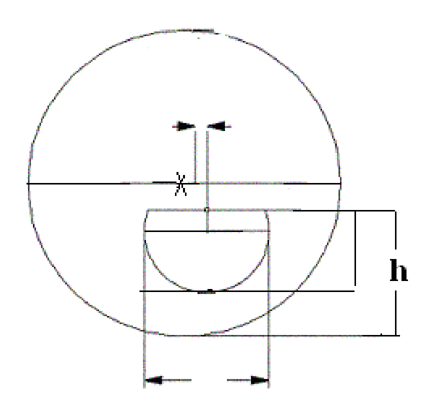
The point in which the visual axis pass through it when looking at distance.

9. Near optical center:

The point in which the visual axis pass through it when looking at near.

It is usually 8 mm below the datum line and 2 mm in from the distance optical centre.

- To determine the vertical displacement of the segment, we take the distance between the lower eyelid margin to the lower rim of the frame and that must equal to the segment height in round segments but in flat top segment we add 1 or 2 mm.



The bifocal frame is preferred to be:

- Square like-shape and relatively large.
- Has movable nose pads.
- Does not press on temple or cheeks.
- The patient should wear the frame and then we take the measurements.

Indication for prescribing bifocal lenses:

- Presbyopia:

It is a condition that affects every person above the age of 40 years.

The human near focus system gradually becomes unable to focus on objects that are closer in. At that point, the prescription that helps people to see objects clearly at distance is no longer sufficient to see close objects also.

- Aphakia:

It is the case in which there is no crystalline lens, the reason is due to trauma or congenital or other causes.

And since the crystalline lens is responsible for accommodation and in aphakia there is no lens, so the patient cannot accommodate.

- So the patient must be corrected for near, by giving him a + 3.00 DS. Addition.

Disadvantages of bifocal lenses:

1. When the amount of addition increase with age, the difference between the two powers increase and so there is no intermediate portion in it.
2. The image jump.

Multifocal Lenses

Other types of bifocal lenses:

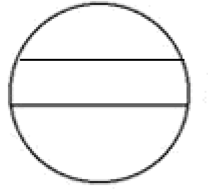
• Double-Segment Bifocals:

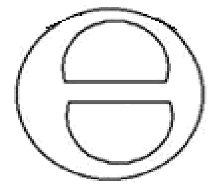
A double-segment bifocal lens has two segments, one below eye level and the other above eye level; the lens is intended for use by electricians, painters, and others whose occupations require close work above eye level.

Most lenses are of the straight-top variety and are available in both fused and one-piece styles. In almost all these lenses, the separation between the upper and lower segments is 13 mm.

The first double-segment bifocal introduced was the Univis Double D, which was available in 22-mm and 25-mm segment widths. American Optical makes the Executive in double bifocal form.

In most double bifocals, the power of the addition in the upper segment is equal to that of the addition in the lower segment. The exception is the Tillyer Double Executive, in which the upper segment has approximately two-thirds the power of the lower segment. For example, for a lower segment power of +1.50 D add, the upper segment has an addition of +1.00 D, and for a lower segment having an add of +2.50 D, the upper add is +1.75 D.

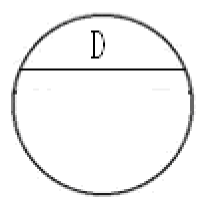




• **Minus Add Bifocal:**

The minus add bifocal is a lens designed predominantly for close work, but it has a relatively small distance-vision window at the top.

Although not widely used, this lens should be considered for a presbyope, such as a barber or postal clerk, whose occupation requires a large field for near-vision work. A minus add lens is currently available in an Ultex-style one-piece form called the Rede-Rite bifocal. Instead of the segment top being located at the upper edge of the wearer's lower eyelid (as in most bifocal fitting), this lens usually has the top of the segment located above the center of the pupil.



• **Blended Bifocals:**

When a blended bifocal lens is manufactured, the line of intersection between the major lens and the segment is blended.

The difference between the two curvatures, at any point in the transition zone, represents cylinder power, usually referred to by lens designers simply as astigmatism.

In fitting and dispensing the blended bifocal, the top of the blended zone should normally be placed 1 or 2 mm above the lower ciliary line, which places the astigmatism-free area of the segment in the most favorable position.

The manufacturer of a blended bifocal places an ink mark on the lens at the upper end of the blended zone, to assist the practitioner in arriving at the segment height.

Trifocal lenses:

A presbyope who requires a near addition of +1.75 D or more is likely to have difficulty seeing at arm's length through either the distance-vision portion or the near-vision portion of his bifocal lenses.

Clear vision at arm's length, however, can be provided by the use of a trifocal lens.Trifocal lenses have an intermediate segment located just above the near segment with a power normally one-half that of the reading addition.

Ay the beginning the height of the intermediate segment was 6mm; later, an 8-mm "occupational" segment was introduced. At the present time, almost all trifocals have an intermediate segment 7mm high.

▪ **Types of trifocal lenses:**

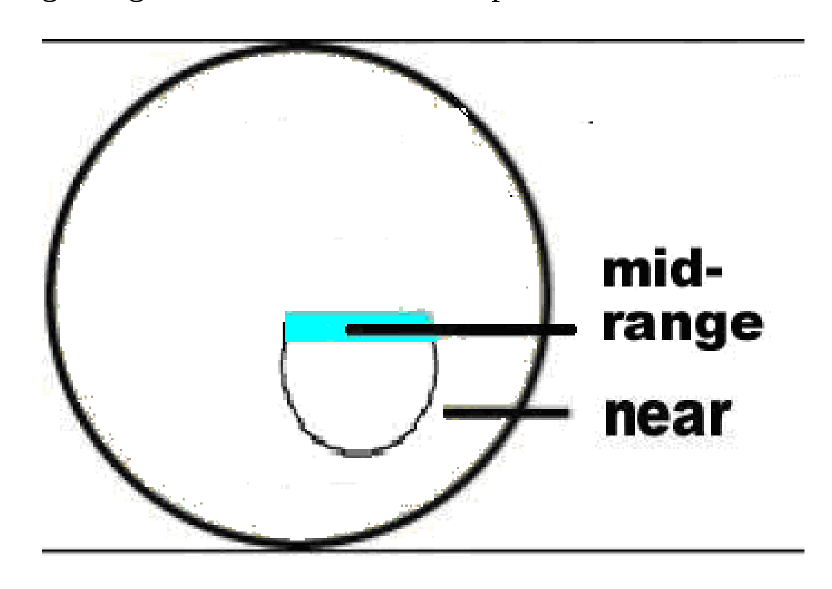
1. Franklin Trifocal:

The Executive, or Franklin-style, lens is a full width segment lens with a 7-mm full width intermediate. It suffers from the same problems as the Franklin-style bifocal lens.

2. Flat-Top and Curve-Top Trifocals:

Flat top trifocal come with intermediate sections that vary in width from 22mm to 35mm and in depth from 6mm to 14mm. the curve top is available only in a 7 × 24 size.

Any trifocal that has a depth greater than 8mm should not be considered an all-time-wear lens. Such lenses are better for situations requiring a large intermediate work component.



3. Round-Segment Trifocals:

Round-segment trifocals are a round bifocal surrounded by an intermediate area, creating a "bull's eye" appearance. They are available in regular add power, as well as high add powers for low vision use.

4. The ED Trifocal:

The ED trifocal combines the characteristics of the Executive-type lens with a 25mm D (flat-top) segment. It is constructed as an Executive lens is constructed, in which the intermediate power occupies the lower half. Into this lower portion a flat-top segment is placed that adds still more power. This brings the near segment area up to the full prescribed add power needed for a near working distance.

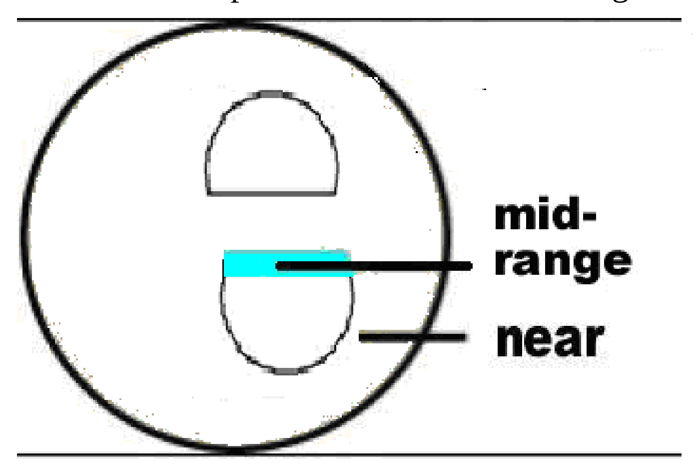
The lens is excellent for working at a desk. Intermediate viewing is available not only in the area 8mm above the near seg, but also on either side of the segment. This gives clear vision for wide, arm's length working area in every direction.

Trifocal lenses limitations:

1. They are not suitable for anisometropes.
2. They are not suitable when a special prism is required.

Quadrifocals:

Quadrifocals are useful for patients who not only require the intermediate-vision range of a trifocal lens but also perform much close work above eye level. All current quadrifocals are straight-top fused construction. Some patients report that these lenses restrict their field of view for non occupational uses such as driving.



Progressive Lenses

In progressive addition lenses, there is a continuous downward transition of lens power from a stable distance power in the upper portion of the lens through a progressive zone to a stable near-vision portion in the lower area of the lens.

The increase in power is caused by an increase in curvature in the progressive zone; that is, there is a progressive decrease in the front surface radius of curvature between the constant radius of the distance portion and that of the near portion.

A progressive addition lens is a one-piece lens having distance and near portions that are relatively stable in power and free of aberrations; the progressive zone extends across the entire width of the lens and connects the distance and near-vision portions.

The central portion, which is the usable area of the progressive zone, is known as the progressive corridor. Within the progressive corridor, the power increases continuously from the distance to the near portion of the lens. All powers between the distance and near prescriptions are present in the progressive corridor. There is no visible reading segment and there are no dividing lines; hence there is an absence of image jump.

The advantages of clear vision at all distances and the absence of a visible reading segment are partially offset by areas in which the aberration of astigmatism is present. The astigmatism occurs because a progressive addition surface (normally the front surface of the lens) is produced by generating an aspherical curvature, a process that produces local and gradual variations in refractive power as well as astigmatism. It is impossible, both mathematically and physically, to design and construct a progressive addition lens that does not produce astigmatism in the lateral portion of the progressive zone.

The principal parameters of a progressive addition lens are interrelated, and include:

(1) The size of the distance and near areas.

(2) The types and intensity of the aberrations.

(3) The depth and usable width of the progressive corridor.

When an aspherical surface with a variable radius of curvature is generated, the inherent astigmatism found to the right or left of the line at the center of the progressive corridor is proportional to the rate of change in curvature. Hence, there are two basic designs of progressive addition lenses. They are referred to as hard and soft designs, referring to the amount and distribution of the astigmatism on the convex lens surface.

• ***The hard design:***

It is created by having a short progressive corridor. And a large area of the lens is free from astigmatism. For the wearer, the advantage of the hard design is the presence of large distance and near-vision zones that are free of astigmatism. The drawback of the hard design is that the area of high aberrations adjoining the progressive corridor and the near add areas produces strongly blurred vision and spatial distortion.

• ***Soft design:***

It has a long progressive corridor that extends into the lateral portions of the distance and near areas of the lens. However, this design provides smaller areas of high-quality imagery in the distance and near-vision portions of the lens. Also, the soft design imposes a lower location of the near-vision add area, which forces greater eye or head movements to use that area.

Hard Designs	Soft Designs
Wider areas in both distance and near	Narrower area at distance and near
Shorter distance down to near viewing	Longer distance down to the near viewing area
Narrower intermediate	Wider intermediate
Longer adaptation	Shorter adaptation
Some apparent curving of straight lines	Less apparent curving of straight lines
Highest dioptric value of peripheral distortion larger than soft designs	Highest dioptric value of peripheral distortion less than hard designs

Hard designs offer large fields of view for distance and near-vision areas, but they impose more intense peripheral aberrations and spatial distortions adjacent to the progressive corridor and near-vision area. Soft designs offer less noticeable blurring and spatial distortion in the periphery, but provide smaller fields of sharp vision in the distance and near-vision portion of the lens.

Symmetric Versus Asymmetric Designs

When both lenses are created in a single symmetric design, there is no difference between a right and left lens blank.

Right-and left- specific designs are referred to as being asymmetric.

Negative Aspects of Wearing Progressive Lenses

Three major negative aspects to the wear of progressive addition lenses can be noted:

Advantages	Disadvantages
The "segment" is invisible	Horizontal lines appear humped when viewed through the lower portion of the lens.
There is no image jump.	Peripheral distortion and "swim"(movement of objects with head movement) may be apparent with some lenses.
There is no ring scotoma around the segment.	Less width of intermediate viewing field than with trifocals.
Good acuity is possible at any viewing distance.	Less width of near viewing field than most bifocals for many progressives.
Viewing more closely.	Increase in lateral head movement.
There is no sudden change in lens power.	Wearer must drop eyes farther to achieve full plus correction.

Good Candidates:

Ideal candidates are those who require an addition for certain tasks but who prefer that the addition not be visible to others. Similarly, those presbyopes who find image jump annoying or are irritated by the segment line itself may be self motivated to adjust to progressive power lenses.

Careful consideration is recommended before advising progressive addition lenses for those with any history of difficulties in adapting to changes in lens powers or frame styles.

Poor Candidates:

Poor candidates are those who have motion sickness or balance problems. Examples include those who suffer from "car sickness", "sea sickness", or similar indications of vertigo. Also included are those with inner-ear problems. All of these require a second look when considering progressive addition lenses, particularly if a harder lens design is being considered.

Selecting the Frame:

The factors of primary importance in selecting a frame for a progressive addition lens wearer are as follows:

1. The frame must have sufficient vertical depth. If the frame selected is not sufficiently deep, it is entirely possible to completely cut off the near portion of the lens (22mm at least from the pupil centre to the lower rim).
2. The frame must have sufficient lens area in the inferior nasal portion where the progressive optics is found.
3. The frame should have adjustable nose pads.
4. The frame should be fitted at as close as a vertex distance as possible to provide a wide lateral field of view through the progressive corridor and the near area.

Prescription Measurements:

Lateral Measure (Interpupillary Distance):

To ensure that the wearer looks through the lens at the locations of maximum optical clarity, the lines of sight must not only pass through

the appropriate distance portion, but also, when the eyes are dropped, pass through the middle of the narrow channels to end up in the centers of the near portions.

Standard Method for Taking Progressive Lens Fitting Measurements

1. Measure monocular distance PDs.
2. Fit and fully adjust the actual frame to be worn (including nose pad alignment) for pantoscopic tilt, height, vertex distance, and face from.
3. If the frame does not contain glazed lenses or the wearer's old lenses, place clear, transparent tape across the eyewire of the empty frame.
4. With the wearer looking straight ahead, draw a horizontal line bisecting the pupil across the lens or tape.

The Varilux Lens

The original Varilux lens, now called the Varilux 1 designed in which the upper half of the lens had no progression in power. The progression was confined to a 12-mm-deep zone in the center of the lens, throughout which the power increased in a linear fashion. Below the progressive corridor was a zone of maximum addition having a constant power and a width of about 22mm.

The astigmatism-free progressive corridor of the original Varilux lens was approximately 5mm wide.

Varilux 2 lens has a wider corridor and so designed to reduce the intensity of distortion in the peripheral areas of the lens compared with the original Varilux, so it is a softer design than Varilux 1.

Anisometropic Problems with Bifocal Glasses

Vertical prismatic effects that differ for the two eyes are likely to cause symptoms of eyestrain. Such effects occur when a corrected anisometrope either elevates or lowers the visual axes to look through points in the lenses considerably above or considerably below the optical centers of the lenses. These effects are most likely to become a problem when the visual axes are lowered for reading. If the lenses are centered in front of the wearer's pupils for distance vision, lowering

the visual axes for reading induces a base-up prismatic effect for the more hyperopic eye of an anisometropic hyperope or a base-down prismatic effect for the more myopic eye of an anisometropic myope.

For a wearer of single-vision lenses, the differential prismatic effects at the reading level may not be a problem because the head is normally tilted downward in reading, with the result that the reading level may be very little different than the level used for distance vision. However, a bifocal wearer must read through a level that is approximately 10mm below the distance optical centers, with the result that differential vertical prismatic effects at near vision can become a problem.

Example:

If a bifocal wearer is given the distance prescription

OD + 1.50 DS – 1.00 DC x 180

OS + 2.50 DS

The powers in the vertical meridian are +0.50 D for the right lens and +2.50 D for the left lens. If the patient reads at a level 10 mm bellow the distance optical centers, the vertical prismatic effects are

OD prismatic effect = 1 (+0.50) = 0.50 prism diopters, base-up

OS prismatic effect = 1 (+2.50) = 2.5 prism diopters, base-up,

And the differential prismatic effect is

2.0 prism diopters, base-up, left eye.

Note: that the power of the add does not enter into the situation as long as it is the same for both eyes. In fact, it is not necessary to specify the power of the add.

Duke-Elder suggested that, as a general rule, a differential vertical prismatic effect at the reading level does not cause symptoms of asthenopia unless it amounts to 1 prism diopter or more.

Procedures which may be used to compensate for differential vertical prismatic effects at the reading level:

1. Lowering the distance optical centers.
2. Prescribing single-vision lenses for reading only.
3. Prescribing dissimilar bifocal segments for the two eyes.

4. Prescribing prism segments.
5. Prescribing a slab-off lens.
6. Prescribing a Fresnel press-on prism.
7. Prescribing contact lenses.

• *Lowering the distance optical centers:*

For example, if the optical canters are dropped 3mm relative to their normal positions, the amount of vertical imbalance is reduced by a factor of 0.3 multiplied by the amount of anisometropia in the vertical meridian.

The amount of vertical imbalance not present at the reading level is present at the positions of the original optical centers (but opposite in direction). For the reason, this method is unsatisfactory.

• *Prescribing single-vision lenses for reading only:*

The patient can wears two pairs of glasses, one for distance vision and one for reading. The distance lenses are centered in the usually manner, with the optical centers positioned in front of the pupils for distance vision. For the near-vision lenses, the optical centers are positioned lower in the lenses, usually 5 to 10 mm lower than their placement for distance vision.

The patient can also use two pairs of glasses, a pair of bifocals for general wear and a pair of single-vision glasses with the optical centers lowered for reading. The bifocals are worn for distance vision and for short periods of near worn but the single-vision glasses are worn for prolonged periods of close work.

• *Prescribing dissimilar bifocal segments:*

Segments of different size or construction, with their centers at different levels, may be used to compensate for an induced vertical imbalance at the reading level.

The amount of compensation is equal to the vertical separation of the segment centers multiplied by the power of the add.

To minimize the difference in the appearance of the segments, it is desirable for the two segments to be as nearly similar in shape as possible. For example, one may use two round fused bifocals with different diameters.

• Prescribing prism segments:

A few bifocal manufactures make available segments with vertical prism power. These lenses are expensive, excessively thick, and are factory orders, involving a delay of several months.

• Prescribing a slab-off lens:

A slab-off lens is made by a procedure known as bi-centric grinding. The front surface is finished in the usual manner (A), after which a dummy lens is cemented onto the front surface (B). the front surface is then reground, using the same tool originally used for that surface, but ground in such a way that the dummy is ground away in the upper portion of the lens but remains attached to the lower portion. The back surface is then finished with the remaining dummy considered as an integral part of the blank (C). The thickness of the blank is then equal at the top and bottom unless the prescription calls for prism in the distance portion. When the lens is finished, the remaining dummy on the lower portion is then removed (D). The dummy is a base-down prism; therefore, this procedure results in the removal of base down prism in the lower portion of the lens, or in the addition of base-up prism in the lower portion of the lens.

The center of curvature of the front surface of the lens in the lower portion, is displaced upward, with the result that the front surface has two centers of curvature, one for the upper portion and one for the lower portion, even though the upper and lower portions have the same curvature. This process results in a unique optical axis for each of the two portions of the lens.

Thus, bi-centric grinding results in the removal of base down prism (whether used on a minus lens or a plus lens), without changing the refractive power below the slab-offline. It is therefore used for the lens that induces the lesser amount of base-up (or the greater amount of base-down) prism, which is always the lens having the less plus or more minus power in the vertical meridian. For example, for the prescription

OD – 1.00 DS

OS – 4.00 DS

Bi-centric grinding would be used for the left lens.

Bi-centric grinding results in a horizontal line across the width of the lens and provides a very acceptable cosmetic result when the line coincides with the segment top of a straight-top bifocal. It may be done on either the front or the back surface of the lens. Front surface bi-centric grinding is used for single-vision glass lenses straight-top fused bifocals, and one-piece glass bifocals (such as Ultex) having the bifocal on the back surface. Back surface bi-centric grinding is used for one-piece straight-top glass executive-style bifocals and trifocals and for plastic single-vision lenses, bifocals, and trifocals.

Recently, it was introduced plastic single-vision and bifocal lenses with a slab-off lens molded or cast with base-down prism in the segment area, rather than individually generating a base-up prismatic effect bi-centric grinding. These lenses are know as reverse slab-off lenses. Because the compensating prism is base-down rather than base-up, the slab-off lens is prescribed for the eye requiring the more plus or less minus power in the vertical meridian. These lenses can be maintained in the laboratory's inventory as semi finished lenses, which makes possible much faster delivery than that for individually produced slab-off lenses.

Slab-off lenses are not usually produced for less than 1.25 prism diopters of compensation because in such cases a sharp, horizontal, straight line is difficult to produce. When more than 1.25 prism diopters of compensation is required, the use of a slab-off lens is the method of choice. The slab-offline is relatively inconspicuous and, in straight-top fused bifocals, the slabbed-off area extends beyond the segment to the distance portion of the lens.

Although bi-centric grinding is expensive, but the advantage is that a larger amount of prism can be provided. The amount of prism possible is limited only by the thickness of the lens.

• *Prescribing a fresnel prism:*

A fresnel prism, is a plastic "press-on" prism, based on the fresnel principle, that can be placed on an ordinary spectacle lens.

A Fresnel prism can be placed on the back of the segment area of a bifocal lens.

Disadvantages of Fresnel prisms are that they give the lens a striated appearance and lower the wearer's visual acuity by about one line of letters on the Snellen chart.

• ***Prescribing contact lenses:***

For an anisometrope who is motivated to wear them, prescribing contact lenses can be an effective method of avoiding differential vertical prismatic effects at the reading level. Contact lenses may be considered as the treatment method of choice for some prepresbyopic patients because well-fitted, single-vision contact lenses remain centered with respect to the pupils when the eyes move downward for reading.

Although bifocal contact lenses have achieved only limited acceptance by both practitioners and wearers, it is likely that the reading level for a wearer of these lenses is considerably higher than that for a wearer of bifocal spectacle lenses. There should be a much smaller differential prismatic effect than that induced by the wearing of bifocal spectacles. The very popular monovision method of fitting presbyopes with contact lenses (fitting a distance lens for one eye and a reading lens for the other) is also effective in eliminating differential prismatic effect at the reading level. Differential prismatic effects also can be avoided for a presbyope if the person is willing to wear contact lenses for general wear, supplemented by spherical spectacle lenses for reading. If the contact lenses are removed, the presbyope may use a separate pair of glasses (centered for the reading level) for reading.

Chapter Nine
Absorptive lenses

Absorptive lenses

Visible and nonvisible light:

Light is electromagnetic radiation found in the wavelength range that includes infrared (IR), visible, and ultraviolet (UV) radiation.

Not all of these wavelengths cause an activation of photoreceptors that produce vision.

Light is interepted as color according to the length of light wave that strikes the retina.

The visible spectrum is considered to be between 380 – 760 nm.

Much of the light in the UV and IR regions of the spectrum that strikes the eye never reaches the retina. Instead it is absorbed by the cornea, aqueous humor, crystalline lens, or vitreous humor of the eye.

If too much of this light is absorbed by the individual eye structure in sufficient quantity or over an excessively lengthy period, it can be harmful. And so these effects can be controlled if absorptive lenses are worn.

Lenses made of clear ophthalmic crown glass or clear CR-39 plastic transmit about 92% of incident visible light, 8% are lost by reflection at the front and back surfaces, but these lenses transmit somewhat smaller amount of radiation in UV and IR regions of the spectrum. And so to increase the absorption in these regions we can add absorbers to these lenses.

Methods of manufacturing absorptive lenses:

An absorptive lens is one that is used for the specific purpose of reducing the amount of transmitted light or radiant energy, thus it acts as a filter.

Absorptive lenses are sometimes referred to as tinted or colored lenses because they are not usually clear and colorless.

The absorption may be uniform (neutral), absorbing visible light of all wavelengths, or selective absorbing some wavelengths more than others.

The major forms of absorptive lenses produced are:

1. Tinted solid glass lenses
2. Glass lenses with surface coating
3. Tinted plastic lenses
4. Photochromic lenses
5. Polarizing lenses

• ***Tinted solid glass lenses:***

To produce a tinted glass lens one or more metals or metallic oxides are introduced into the basic batch at the start of the process.

The elements most commonly used and the colors they produced are:

Iron	Green
Manganese	Pink
Cobalt	Blue
Cerium	Pinkish brown
Nickel	Brown
Uranium	Yellow
Chromium	Green
Gold	Red
Silver	Yellow

• ***Glass lenses with surface coating:***

A lens is tinted by depositing a thin metallic oxide on the surface of the lens.

The coating is deposits on the lens by an evaporation process conducted under a vacuum at high temperature.

Because of the high temperature required, the vacuum coating process cannot be used with plastic lenses.

• ***Tinted plastic lenses:***

Plastic lenses cannot be surface coated by evaporation because they would be deformed by the high temperature required. Consequently; plastic lenses are tinted by dipping them in a solution containing the appropriate organic dye.

If the tint is too dark, or for any reason needs to be changed, some tint can be removed by dipping the lens in a bleaching solution.

Color characteristics:

Characteristics of the major lens colors:

- Clear crown glass and CR-39 plastic:

All UV light below 290 nm is absorbed by crown glass. Unfortunately, it is the UV between 290-390 nm can be more disturbing. CR-39 plastic used in normal spectacle lens wear contains a UV inhibitor that blocks UV below 350 nm.

- Pink:

Pink is a tint that has been widely used in the past and continues to experience a mild popularity. Pink tints have a uniform transmission across the visible spectrum and therefore do not cause any color distortion for the wearer.

Pink tints are often used for unfavorable indoor lightening situations, such as bright fluorescent lightening or glare in the work area. The best solution to those problems is a change in lightening rather than an indoor tint.

- Yellow:

Yellow-tinted lenses are especially subject to myth and speculation. Traditionally used as a shooting glass, many sportsmen believe their shooting ability is improved by a yellow tint.

Any lens, including a yellow lens, that absorbs light in the blue end of the spectrum can be helpful in reducing glare from light scattered by the atmosphere, for example, as from a blue sky. Yellow lenses are not advisable for night driving.

- Brown:

Brown or gray – brown lenses are most often used for sun lenses in Germany and other middle – European countries.

Brown lenses have some of the same characteristics as yellow lenses in that there is a higher absorption of shorter visible wavelengths. By reducing the transmission of the blue end of the

spectrum, brown lenses, like their yellow counterparts, are also commonly thought to improve contrast on bright, hazy, or smoggy days.

- Green:

Green sun lenses have a transmission curve that closely approximates the color sensitivity curve for the human eye. They were first made popular through use in military but have now been fairly well replaced by the neutral gray lens. The green – tinted glass lens obtains its color and characteristic transmission curve from ferrous (iron) oxide.

There is good absorption in both the IR and UV regions.

- Grey:

Gray is a tint most popular for sun protection and with good reason. Perhaps the best aspect of gray is its evenness of transmission through the whole visible spectrum.

This characteristic allows colors to be seen in their natural state relative to one another. For this reason, neutral gray is quite satisfactory for use by those with color vision deficiencies.

• *Photochromic lenses:*

There are lenses that darken when exposed to long wavelength UV radiation. Photochromic glass with an index of 1.523 contains microscopic crystals of silver halide. O absorption of long wavelength UV radiation, the silver halides crystals decompose into silver and halogen atoms and the lens becomes darker. The rigid matrix of the glass holds the silver and halogen in close proximity and, on removal of the activating UV radiation; the silver and halogen atoms recombine into silver halide crystals, with the result that the lens becomes lighter.

• *Polarization lenses:*

The beam of light is said to be unpolarized, some types of crystals, such as quartz have the property of either partially or totally suppression the vibration in a particular direction.

Polarizing filters are made by heating and stretching a thin sheet of polyvinyl alcohol to about four times its original length.

The stretching aligns the molecular structure into long chains parallel to the direction of stretch.

The sheet is then passed through a week iodine solution and the iodine molecules diffuse into the polyvinyl layer and attach themselves to the chain of long molecules, which thereby creates a polarizing filter.

Polarizing lenses offer distinct advantages to fishermen who experience glare from the surface of the water, and also to motorists and skiers.

The lens coatings

Antireflection coatings:

An antireflection coating is a thin, clear layer or layers applied to the surface of a lens

• ***The purpose of antireflection coating:***

1. Reduce unwanted reflection from the lens surface.
2. Increase the amount of light that actually passes through the lens to the eye.

Uncoated crown glass transmits 92% of the incident light. If single-layer AR coating is used, transmission jumps to approximately 98%, whereas if a multilayer AR coating is used, transmission is increased to over 99%.

Antireflection coating uses the principle of destructive interference to reduce the reflection.

• ***Antireflection coating of pretinted lenses:***

Pretinted lenses, glass or plastic, may also be antireflection coated. This is quite advantageous in several situations. It should be remembered that once a dyed lens has been antireflection coated, it cannot be either bleached to a lighter color or redyed to a darker color.

• ***Pros and cons of antireflection coatings:***

The pros of an AR-coated lens are both subjective ones noticed by the wearer and objective ones seen by an observer.

Pros

Subjective advantages noticed by the wearer include better light transmission, decreased glare, and improved night vision. There is also a loss of the star-like flare from self-illuminated objects such as headlights, and street lamps.

Objective advantages include the loss of surface lens reflections. Without lens reflections, the wearer's eyes become more visible. Because edge reflections are reduced and the lens appears less visible, AR coatings make thick lenses appear thinner.

Cons

The cons of AR-coated lenses begin with cleaning. Because the AR coating works if it is the first surface that light strikes when entering the lens, any dirt, water, or skin oils will reduce the effectiveness of the coating.

AR coatings exaggerate the contrast between clean and dirty areas.

When mistreated, AR coating can peel and separate from the lens.

Scratch-resistant coating:

Because of the tendency of plastic lenses to scratch more easily than glass lenses, manufacturers have developed processes for coating the plastic lens to develop more surface hardness and thus more resistance to scratching. An uncoated CR-39 plastic lens transmits approximately 92% of the incident light. Antiscratch coating the lens may increase this to just short of 96%.

Lenses with antiscratch coating should not be exposed to excessive heat

Antifog coating:

Antifog coating are used for individuals who are constantly going into and out of changing temperature environments or who are exposed to other environmental conditions that would fog lenses. Wearers who may appreciate antifog coatings include cooks, ice skaters, and skiers.

Mirror coating:

A mirror coating can be applied by a vacuum process to the front surface of the lens, causing the lens to have the same properties as a mirror. The observer, unable to see the wearer's eyes, sees his or her own image reflected from the lens. The wearer is able to look through the lens normally. There is, of course, a reduction in the transmission of the lens simply because of the high percentage of light reflected. Mirror coatings are often used in combination with a tinted lens to provide more protection from intense sunlight than the mirror coating alone can provide. Mirror coatings are also good reflectors of UV and IR, usually reflecting more UV and IR than they do visible light.

Chapter Ten
Special Lens Designs

Special lens designs

Aspheric lens:

The term aspheric means "not spherical". A spheric lens surface is regular, like the surface of a ball or sphere. That surface has one specific radius of curvature. An aspheric lens surface changes shape: It does not have the same radius of curvature over the entire surface.

• ***Purposes for using an aspheric design:***

There are four primary reasons for producing a lens that has an aspheric surface:

1. To be able to optically correct lens aberrations.
2. To allow the lens to be made flatter, thereby reducing magnification and making it more attractive.
3. To produce a thinner, lighter-weight lens.
4. To make a lens with progressive optics.

• ***Asphericity for optical purposes:***

As stated earlier, it is possible to produce a lens that is optically sound for most power using regular, spherical surfaces. Once lens power go beyond the +7.00 D to -23.00 D range, however, it is necessary to use an aspheric design.

In the middle, an aspheric lens surface starts out as any other spherical surface starts out. Then at a certain distance from the OC, the lens surface gradually changes its curvature at a rate calculated to offset peripheral aberrations.

• ***Asphericity for flattening purposes:***

For lenses with spherical base curves, higher plus power always results in steeper base curves. Unfortunately, the steeper the base curve, the worse the lenses look. Choosing a flatter base curve will make the lens look less bulbous and also reduce magnification. Cosmetically, the lens looks much better. It even looks considerably thinner than before, although in reality it is only slightly thinner. Because flat base curves reduce magnification, the wearer's eyes do not look as big.

Another reason for flatter base curves:

The steeper the base curve, the easier it is to dislodge the lens from a metal frame. So, it is not unusual for a laboratory to flatten a base curve to make it fit more securely in the frame. Yet, rather than flattening a regular lens, a better option is to use a flatter, aspherically designed lens.

• ***Asphericity for thinning purposes (Geometric Asphericity):***

Asphericity can be engineered with the express purpose of making the lens thinner. To do this for plus lenses, either or both the lens front and back surfaces are flattened quite a bit toward the edge. Flattening the periphery makes it possible to grind the whole lens thinner.

To thin minus lenses, the lens front surface is steepened; the back surface is flattened toward the periphery, or both. This reduces edge thickness.

• ***Asphericity for producing progressive power changes:***

By definition, any lens surface that is not spheric is aspheric. Progressive addition lenses achieve their add power gain from a progressively steepening surface curvature. So, progressive addition lenses are also aspheric lenses.

Note: use monocular interpupillary distances.

High plus lens design:

Before the advent of intraocular lens implants, high plus lenses were much more prevalent.

• ***Regular spheric lenses***

It is possible to use a regular, spherically based lens for a high plus wearer, even though the optics is not as good.

• ***Lenticulars***

A lenticular lens is one that has a central area with the prescribed lens power surrounded by an outside area of little or no power. The central area is called the aperture, and the outer area is called the carrier. The lenticular style was developed for the purpose of thinning the lens. It is similar to a small plus lens that is attached to a thin Plano lens.

Lenticular lenses are available as either spheric or aspheric lenticulars.

Aspheric lenticulars have an aspheric aperture. An aspheric lenticular can be thought of as a small, aspherically designed plus lens that has been placed on a near-plano carrier. Of the two lenticular designs, the aspheric lenticular is the better choice.

Advantages of a lenticular design

The main advantages of the lenticular design are weight reduction; thickness reduction; and, for aspheric lenticulars, good optics.

Disadvantages of a lenticular design

The main drawback to the lenticular design is looks. Even for small eyesizes, the edge of the aperture is usually visible.

Multidrop lenses:

The Welsh 4-Drop lens was developed in an effort to overcome the cosmetic negative of the lenticular design while maintaining a thin lens.

Outside the central area, the lens surface dropped in power, 1 D at a time for a total of 4 D. for example, if the lens had a central base curve of +14.00 D, there were four outer concentric areas with powers of +13.00 D, +12.00 D, +11.00 D, and +10.00 D. each area blended into the other so that the changes in power were not visible.

The optics was less than ideal, but the lens was thin and better looking. The general category of lenses that emerged became known as multidrop lenses.

High minus lens designs

Perhaps the greatest lens problem facing the high minus wearer is thick edges.

Many of the options for high minus lenses may not be needed if the dispenser first applies traditional dispensing principles such as small effective diameter size, high-index lenses. Yet if lens power is high enough, these measures may still prove insufficient. If this happens, a special high minus lens design is in order.

• *Lenticular minus designs*

A lenticular design for a high minus lens uses the same idea as the lenticular design for high plus lenses. The central area of the lens contains the prescribed refractive power of the lens. The peripheral (carrier) area serves only to extend the physical size of the lens without increasing its thickness.

Lenticular minus lenses can be found in a variety of forms. The most common forms are the myodisc, minus lenticular and the younger blended myodisc.

1. The myodisc

According to the traditional definition, the myodisc design has a front surface that is either flat or almost flat. The front usually contains the cylinder component of the prescription. A myodisc also has a plano back carrier area. There is a high minus "bowl" in the middle of the back surface.

In a myodisc, since the carrier is near Plano, its thickness is constant. The larger the bowl area, the thicker the carrier. For lenses with the same sized bowl areas, increases in lens power will mean increases in carrier thickness.

Because the myodisc carrier is plano, edge thickness can still be significant. It is possible to reduce edge thickness further by using a variation of the myodisc. That variation is called a minus lenticular.

2. Minus lenticular

A minus lens with a lenticular design can be made so that the carrier is not plano but is plus in power. By making the carrier positive, the outer edge will thin down. Such a lens is called a minus lenticular design.

3. The younger blended myodisc

This lens has the advantages of the minus lenticular design, and erases the line between bowl and carrier so that it is not seen. This type of lens is referred to as a blended myodisc.

Chapter Eleven
Fresnel prisms

Fresnel prisms

What is a fresnel prism?

A traditional prism has two flat, nonparallel surfaces. Parallel light entering the prism is bent toward the base of the prism and leaves the back surface at an angle. A prism is thicker at the base than at the apex. The larger the prism, the thicker the base of the prism will be.

A Fresnel prism attempts to circumvent thickness by building a "tower" of small, wide prisms. To understand how a Fresnel prism works, imagine cutting off the tops of a large number of equally powered prisms and gluing them, one above the other, onto a thin piece of plastic. A fresnel prism is only 1 mm thick.

What are the advantages of a Fresnel prism?

There are several advantages of a Fresnel prism. First, it is very thin and extremely lightweight. It is flexible and can be applied to an existing spectacle lens.

Because the lens is made from a soft, flexible material, it can be cut to any shape with scissors. This means that it can be cut and applied to one sector of a lens.

What are the disadvantages of a Fresnel prism?

Fresnel prisms look different than conventional lenses. They are different enough that they may be noticed by others. Because Fresnel have a number of small ledges, they are harder to clean than conventional lenses.

High-powered prisms will cause a slight decrease in visual acuity. Most of this is due to the chromatic aberration and distortion associated with prisms; also it can be due to reflections at the prism facets, especially under certain sources of illumination.

When is Fresnel prism used?

There are a variety of clinical applications for Fresnel prism such as:

1. High amounts of prism:

Because of its thickness advantage, Fresnel prism is especially useful for high amounts of prism.

2. Use and reuse:

Fresnel prism lenses are easily to apply and remove. They may be used and reused. This is helpful when determining how a given prism amount will work long-term or for use during visual training.

3. Sectorial application:

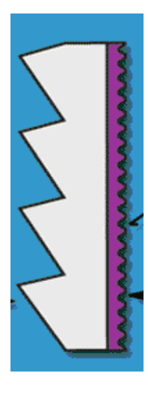
A partially paralyzed extraocular muscle may result in a different amount of prism needed for different directions of gaze. A fresnel lens can be cut to fit that particular lens area. Prism is present only where it is needed.

4. Cosmetics of nonseeing eyes:

We can use prisms to improve the appearance of a blind or prosthetic eye also Fresnel prisms can be used in such cases

5. Slowing of nystagmus:

Nystagmus is a condition characterized by a constant back and forth movement of the eyes. Such movement is involuntary and reduces vision. In some cases, nystagmus may slow when the person looks to one side or the other. For example, if the examiner sees that movement slows when the person look to the right, equal amounts of prism may be applied to both lenses. The correct base direction would be base left. Because the eyes turn toward the apex, prism base left will keep the head pointed straight while the eyes turn to the right. Since the eyes are turned to the right, nystagmus slows.



How to clean Fresnel prisms?

The manufacturer's recommended method of cleaning these lenses is to rinse under warm running water. If the lenses have dirt in the grooves, use a soft brush. Hard contact lens cleaning solution has also been used to clean Fresnel prisms.

Low Vision Aids

Failure of the visual acuity to be corrected to a normal level with standard optical techniques is characteristics of many important ophthalmic diseases, such as: macular problems, age related macular degenerations, high myopia, advanced glaucoma, diabetic retinopathy, and optic atrophy.

In these cases the improvement of vision can be obtained by the use of special optical devices known as visual aids or low-vision aids

A plus lens as a magnifying aid allows a patient to obtain an increased retinal image size by holding the object closer to the eye without placing extra demands on accommodation.

Spectacle Microscopes:

Definition:

A spectacle mounted plus lens used to produce magnification for reading or near point tasks.

Usually of greater power than the traditional maximum for a reading add (+4.00DS)

$$M = \frac{F}{4}$$

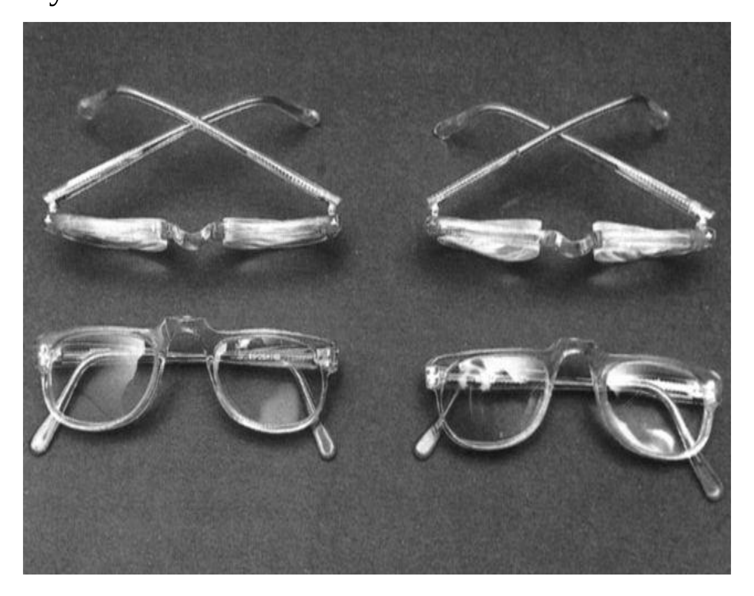
Spectacle Microscopes can be sub-divided into 3 types:

1. High reading additions.
2. Simple Spectacle magnifiers.
3. Compound spectacle magnifiers.

- High reading additions:

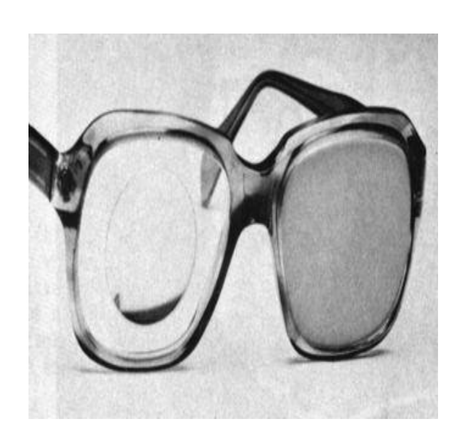
Defined as adds which result in a working distance less than that which the patient would normally have preferred.

1. Generally binocular.
2. Usually > +3.00DS but < +10.00DS



- Simple Spectacle magnifiers:

- Monocular Lens.
- Magnification 2x to 10x.



- Compound spectacle magnifiers:

- It is used when > 10x magnification is required.
- Monocular.

• Working distance is very critical.

When using spectacle microscopes close working distances is required and it is accompanied with too much convergence.

Base-in prism (relieving prism) is often incorporated

1Δ for each eye per dioptre of add

Advantages of Spectacle Microscopes:

1. Patient has hands free.
2. The field of view is maximal as the lens is close to the eye.
3. Similar cosmetic appearance to conventional spectacles.

Disadvantages of Spectacle Microscopes:

1. Very reduced working distance
   - limits writing, sewing etc.
   - Postural discomfort.
   - Illumination difficult.
   - Convergence demands.
2. Have to be removed when walking around.
3. Need to use head movements.

- Hand Magnifiers:

$$M = \frac{Fequivalent}{4}$$

• Low/medium power, non-illuminated. *(up to 6x).*

• Illuminated hand lenses *(up to 12.5x).*

• High powered loupes *(up to 20x).*

Characteristics of hand magnifiers:

• Plus lenses increase retinal image size

• Allow patient to adopt a closer working distance.

• Magnifier-to-object distance is constant.

- Magnifier-to-eye distance can be varied(without affecting magnification).
- Distance Rx should be worn

Advantages of hand magnifiers:

- Easy to use.
- Use with distance Rx.
- Portable.
- Relatively inexpensive.

Disadvantages of hand magnifiers:

- Occupy a hand.
- Restricted field of view.
- Poor if tremor present.
- Distortion.

- Stand Magnifiers:

Non-illuminated low powered

- fixed stand *(up to 4x)*
- flexible stand/chest magnifiers *(up to 4x)*
- bar/flat field magnifiers *(1.5-1.8x)*

Non-illuminated medium/high power

- (up to 20x)

Illuminated units (Halogen)

- fixed stand *(up to 15x)*
- flexible stand *(up to 3.75x)*



Advantages of Stand magnifiers:

- Accurate working distance.
- Hands free use.
- Can have internal illumination systems.

Disadvantages of Stand magnifiers:

- Patient may require a special pair of reading spectacles.
- Stand can prevent access to object.

- Bar & Flat Field Magnifiers:

Bar Magnifier:



Flat Field Magnifier

Solid hemisphere magnifies in all meridians



Telescopes

Telescopes represent an effective way of producing magnification without changing the working distance.

It is often used to focus on objects closer than infinity and it can be modified to correct for the Patient's refractive error.

Disadvantages of telescopes:

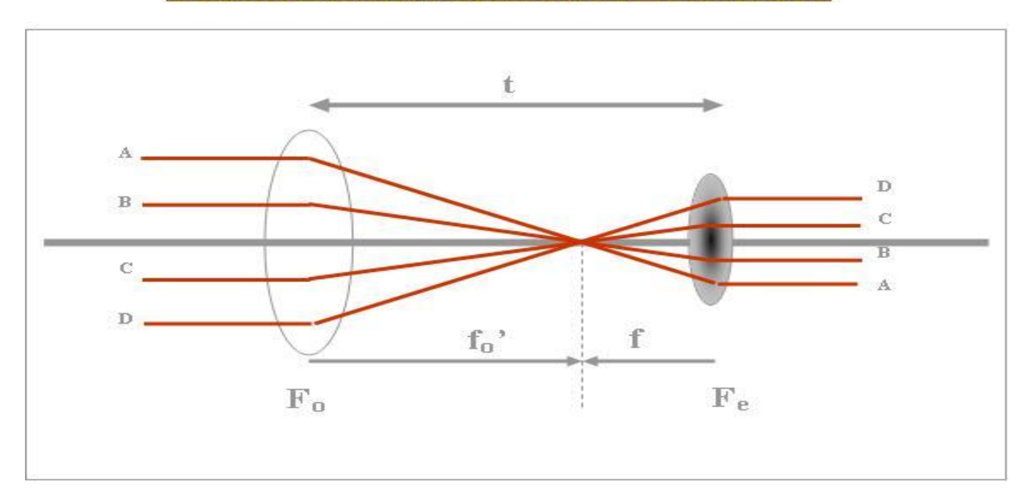
They have a restricted field of view.

There are two basic kinds of Telescopes:

1. Keplerian or Astronomical:

- It consists of a positive objective lens (f_0) and a positive eyelens (f_e).
- The focal points of these lenses are coincident.
- The image formed by a Keplerian telescope is inverted.
- Prism is required to re-invert the image.
- Specified in terms of the magnification and the diameter of the objective lens (e.g 4 * 12).

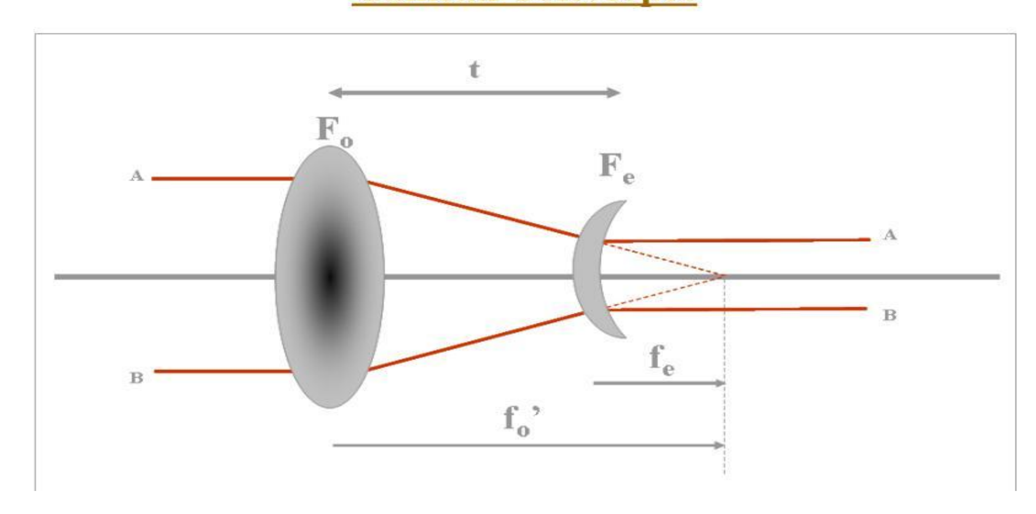
Keplerian or Astronomical Telescopes



2. Galilean Telescopes:

- It consists of positive objective lens (Fo) and a negative eyelens (f_e).
- The image produced by a Galilean Telescope is erect.
- The length of the Galilean Telescope is shorter than the Keplerian
- Specified by the magnification 2x , 2.5x etc.

Galilean Telescopes



Comparison of Keplerian & Galilean Telescopes:

Property	Galilean	Keplerian
Objective	positive	positive
Eyepiece	negative	positive
Tube length	short	long
Magnification	Up to 4 x	Up to 10 x
Field size	smaller	larger

Note: A telescope gives maximum field of view if the objective lens is as large as possible.

Adjusting telescopes according to the patient's refractive errors.

Myope:

Keplerian telescope:

Make tube shorter

Power will be more

Field will be smaller

Galilean telescope:

Make tube shorter

Power will be less

Field will be larger

Hyperope:

Keplerian telescope:

Make tube longer

Power will be less

Field will be larger

Galilean telescope:

Make tube longer

Power will be more

Field will be smaller

Telemicroscopes:

In order to be useful for near work, telescopes have to be modified

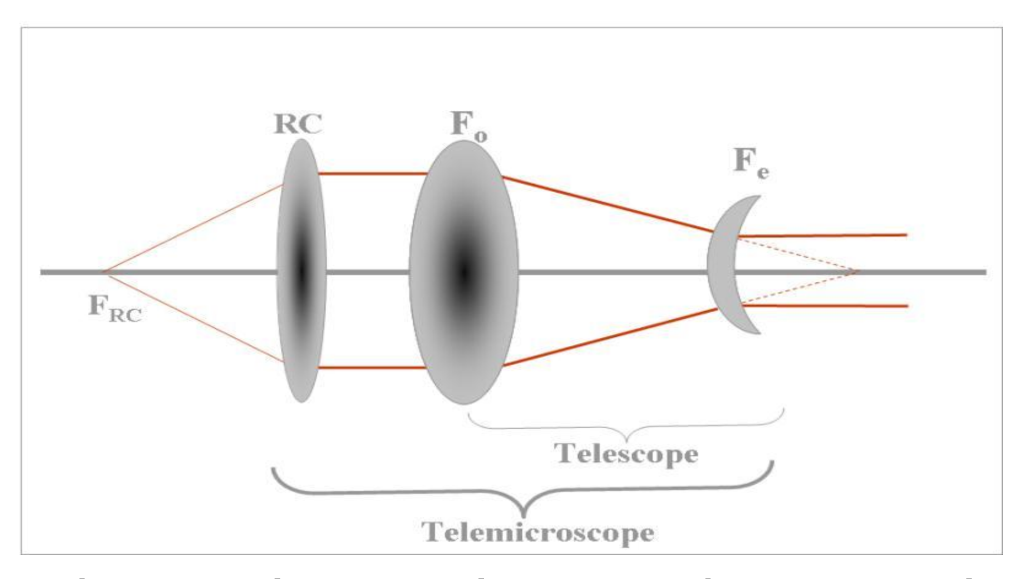
This can be achieved in two ways:

1. Increase the tube length
2. Introduce a reading cap into the device.

This is a positive lens of power equivalent to the required working distance.

Telescopes that are focused by making the tube longer have a slightly higher magnification and smaller field than when caps are used for the focus.

Telemicroscopes



The accommodation required to view an object at a particular working distance through a telemicroscope is given by:

Accommodation = Working Dist. (in Dioptres)* $(M)^2$

E.g. to view an object @ 40cm using a telemicroscope with M = 4x

Accommodation = 2.50 * $(4)^2$ = 2.5 x 16.00

= 40 Diopters

Even small working distances can make high demands on the accommodative effort.

The magnification provided by such a system is the product of the individual components:

M total = M telescope × FRC / 4

When prescribing telescope to a patient we should give him some instructions:

- To locate an object, first view it with your naked eye before lifting the telescope and spotting through it.
- Do not walk or move when viewing through the telescope.
- Objects seen through a telescope seem to be closer than they are.
- To focus a telescope for close distance make the tube longer.

Keplerian or Astronomical:



Galilean Telescopes:



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